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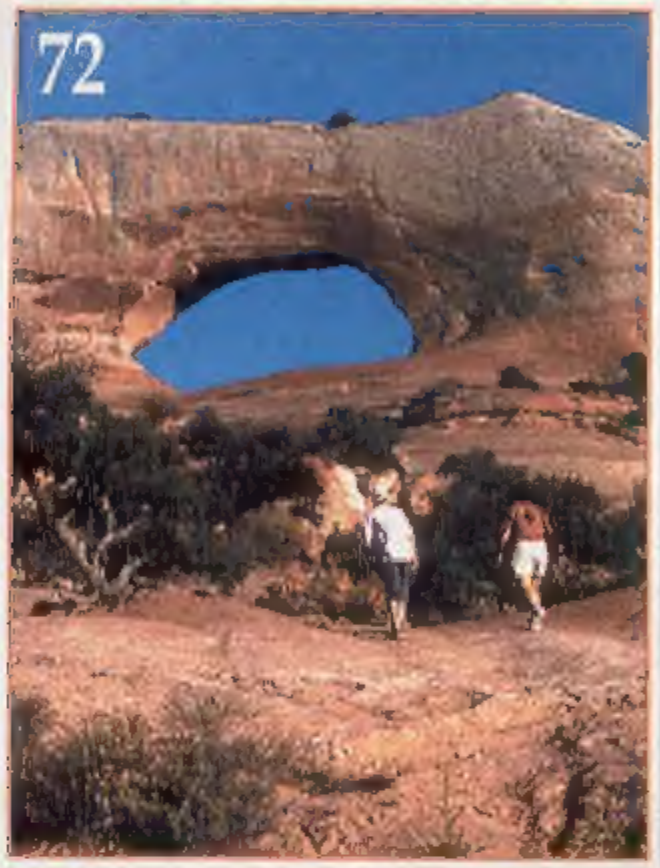

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COVER: Bright-orange wulfenite crystals stand out brilliantly against a background of azurite and malachite. All are from Arizona. (Photo by Earl Lewis)

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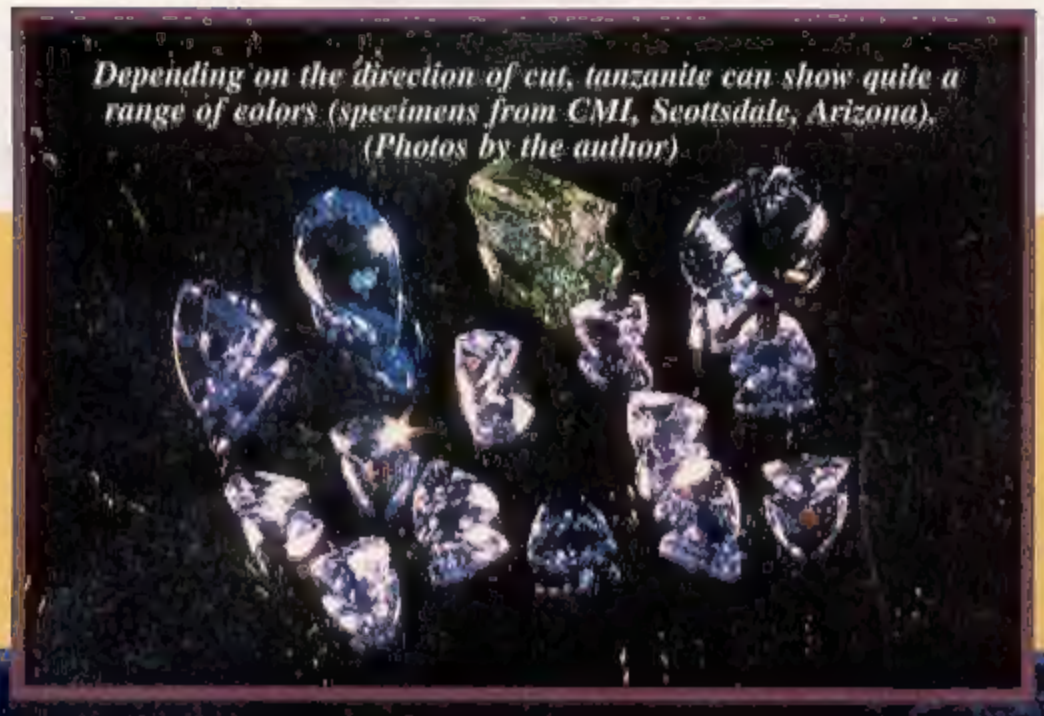
The Gems of AFRICA

A Treasure Chest of Bright Stones from the Dark Continent



Depending on the direction of cut, tanzanite can show quite a range of colors (specimens from CMI, Scottsdale, Arizona). (Photos by the author)

Sugilite, first introduced to the mineral world as Royal Lavulite, is a superb lapidary mineral (Randy Polk specimen).

Iron oxide is the coloring agent in crocidolite from Griqualand, South Africa.

by Bob Jones

Whenever you talk about gems coming from Africa, the immediate thought is of diamonds. But in the last 40 years, a kaleidoscope of gem colors have come forth from the Dark Continent. From emeralds to tanzanites to tsavorites to elbaites and so much more, Africa now rivals Sri Lanka as the world's gem chest.

It all started with Egypt, that ancient civilization on the Nile. Between the Nile and the Red Sea, during the time of Cleopatra, emeralds were dug by slaves to adorn the nation's rulers. By today's standards, the emeralds were not of superb quality, but they were the only game in town.

Just off the coast of Egypt, in the Red Sea, was another gem source, the legendary Island of Topazios, now called Zeberget, or the Island of St. John. This rich source of the green gem peridot was lost in history, but was rediscovered in the early 1900s. Its gems—sometimes huge crystals that cut into gems exceeding 100 carats—are world famous.

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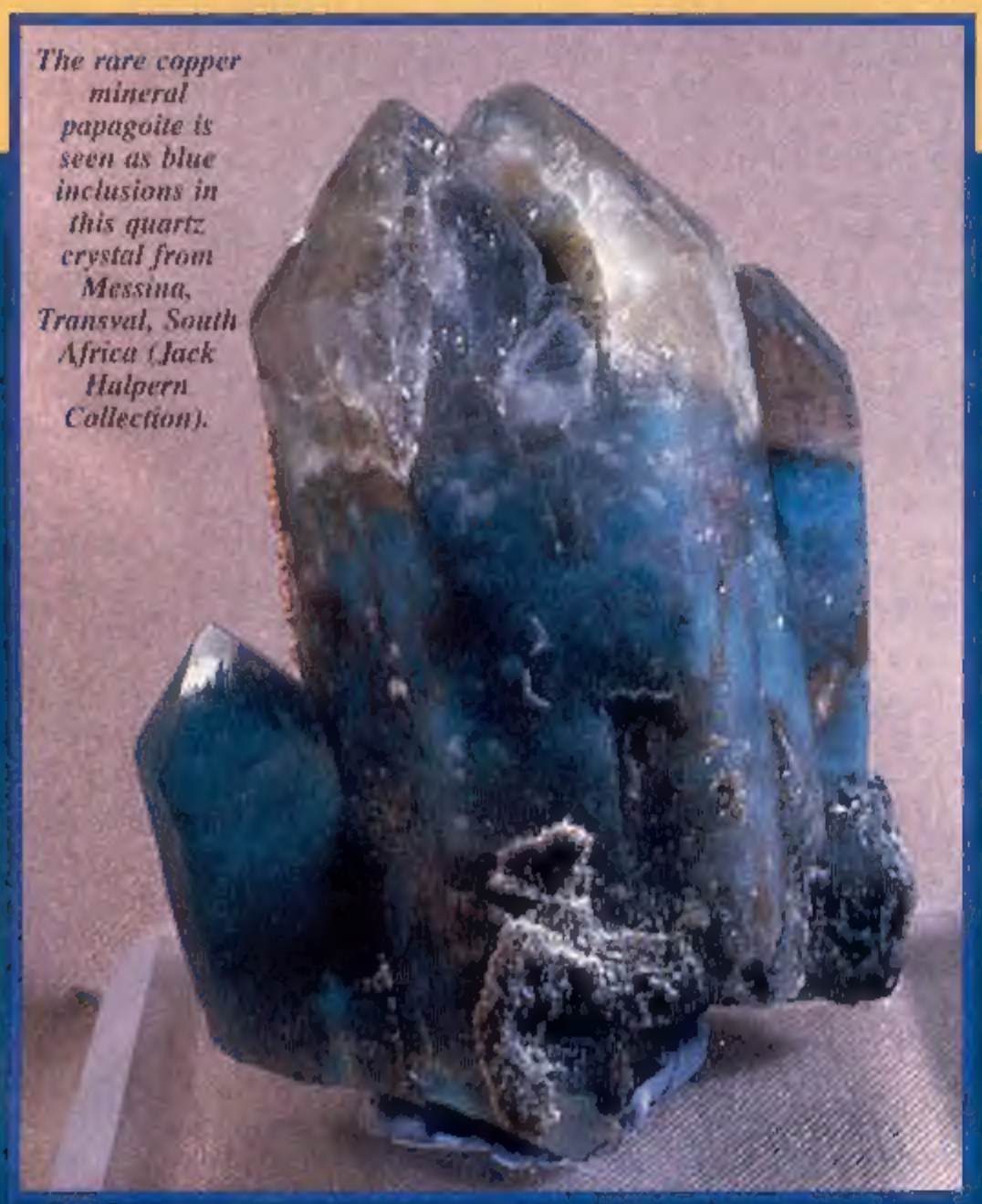


The rare copper mineral papagoite is seen as blue inclusions in this quartz crystal from Messina, Transvaal, South Africa (Jack Halpern Collection).

These sugilite carvings show the beauty of the gem and the variations in shades of violet.

The Gems of Africa *from page 13*

Peridot from Zeberget occurred in veins of nickel ore that cut through a dunite rock. They ranged in color from green to brown, with green the more popular color. Recent studies have determined the brown gems to be sinhalite, a magnesium aluminium borate, while the green peridot, a magnesium silicate, has been assigned the name forsterite. Forsterite forms a chemical series with fayalite, an iron silicate.

When diamonds were discovered in Africa, hunting for other gems was rather an afterthought, as everyone sought the sparkling pure-carbon stones. Small amounts of colored gems were found, but there was no real rush until the 20th century.

When Tsumeb and other copper deposits were discovered, prospectors searched far and wide. In 1922, in the Kalahari Desert of North Cape Province, South Africa, one of the world's richest manganese deposits was discovered. First at Hotazel, and later N'Chwaning, mines developed the black ore deposits.

The first surprise came when vibrant red rhodochrosite crystals were found at Hotazel. These lovely dogtooth crystals were found in crystal plates of breathtaking color and luster. Some of this material was faceted, but most entered the mineral market as specimens.

In 1973, the Wessels mine opened and much more rhodochrosite was mined. More exciting was the discovery of a superb violet massive gem first introduced as Royal Lavulite on the pages of *Rock & Gem*. Another name, Royal Azel, was briefly used. The gemmy violet rock was finally analyzed and found to be a complex potassium, sodium, iron, manganese, aluminum, lithium silicate. Blessed with a royal violet color, sugilite was an instant sensation when it hit the market in the 1970s. With a Mohs hardness of 5.5 to 6.5, sugilite takes a bright polish and has become the darling of jewelers and lapidaries who incorporate its rich color into their work. Sugilite is technically known as manganoan sugilite, as the amount of manganese oxide runs from 1 to 3.5 percent.

Perhaps the most exciting type of what is usually called sugilite is actually chalcedony that has been infused with sugilite, much like chrysocolla infuses chalcedony in copper deposits to form blue gem silica.

Sugilite and its gem companion violet chalcedony occur sparingly in layers up to 6 inches thick in the Wessels mine. Its value has become so great that miners are specifically trained to identify this dark-violet mineral in the black manganese veins. The gem rough is then stockpiled, guarded by armed men and noisy geese, and sold periodically.

Still another wonderful African gem of recent vintage is now called tsavorite. The locals call it tsavolite. In any event, the name was derived from that of a nearby national park. Tsavorite is actually a vanadium grossular garnet with the vanadium content averaging about 3.3 percent. As a garnet, it is hard and suited for gem use.

The initial find was made by a Scottish geologist, Campbell R. Bridges, in the late 1960s, in a locality called the Komole Mine. The deposit produced this vanadian grossular in veins of gypsum in gneiss and marble, but in more or less rounded masses, not euhedral crystals.

In 1974, tsavorite was discovered in the Merelani Hills, which are also the source of tanzanite. It was initially mined from the Karo pit, where crystals of the luscious green gem were found. This discovery was soon the talk of the gem trade, and Tiffany's named this gem after the Tsavor Park, near which it was found.

To add a measure of excitement to the 2002 Tucson Show, the Tucson Gem & Mineral Society (TGMS) has invited Campbell Bridges, who discovered tsavorite, to come to the show and give a lecture on his vast gem-prospecting and mining experiences in Africa.

Of course, the Merelani Hills may be better known for blue gem tanzanite, a variety of zoisite. Bridges brought examples of this gem to New York, where it was identified and promoted by Tiffany's. This remarkable gem skyrocketed to the top of the gem market. Eduard Gubelin and Franz-Xaver Erni, in their superb gem book *GEMSTONES: Symbols of Beauty and Power,* refer to tanzanite as the "Blue Patrician" from Africa. Its vibrant color is a remarkable scientific phenomenon.

The term trichroism is applied to this blue patrician, for it shows three different, distinct colors all in the same crystal! Hold a tanzanite in your hand and gaze through it. In one direction you will see the superb blue color that makes this gem famous. Turn the crystal 90 degrees, and the blue disappears and a lovely violet color emerges. Look down the long axis of the crystal and you'll see a brownish or a greenish color. Therefore, cutting the crystal properly is essential to obtaining the desired blue-violet color.

How does this happen? What mechanism can possibly cause a gem to change color just by being rotated in a different direction? This phenomenon results from the gem's internal molecular structure and the action of electrons within that structure.

As light enters a crystal, it excites electrons in the structure. These absorb some of the light energy, move about, and settle in a new site. The excited electrons can move in several directions, but they don't always travel the same distance to a new site. This affects which light energy waves are absorbed and which are emitted to be seen. So, viewed from one angle, the emitted light will be violet, from another blue, and from yet another brown or green. Other minerals, like tourmaline and epidote, will emit two different colors when viewed from different angles. These are called dichroic minerals. Tanzanite is one of a small number of gems that show three different colors, a delightful color phenomenon.

Zoisite has been a well-known rock for years. It wasn't until 1967 that tanzanite came to light and immediately caused a stir. The initial crystals were studied at the British Museum of Natural History and elsewhere. This new gem was initially called blue zoisite. But those who market gems, recognizing the importance of this new gemstone and the need for a more exotic name, rushed to find one. One fellow came up with "tanjeloffite." Others stuck with "blue zoisite," but eventually "tanzanite" prevailed and remains the gem's recognized trade name.

Much more common and on the market for at least a half century is another form of zoisite, an intense, green, massive metamorphic rock that made up of green zoisite, which dominates the rock, plus black hornblende and bright, massive ruby crystals. This spectacular carving material comes from the Matabatu Mountains near Longido, about 45 miles north of Arusha.

Locally this colorful material is called

anyolite, a name derived from the Masai word for "green." It has also been called Tanganyika Artstone, but it is best known as ruby zoisite. The zoisite is chromiferous, which gives it the green color that forms a wonderful setting for the large, hexagonal, red-violet ruby crystals it encloses. The rubies are almost never gemmy. Instead, they show a striking chatoyance when domed and polished. The outcrops of this carving rock are not very large, usually a few dozen yards long and several yards wide.

Most of the rock mined in the Matabatu Mountains went to Idar-Oberstein for carving, and some stunning gem products were the result. Some marvelous carvings of this red-green material can be seen in museums, especially in Idar. I can recall Jack Greenspan, founder of Crystalite Corp., showing me a stunning 6-inch-wide ruby crystal he was polishing. The crystal was wreathed in green zoisite and its red surface showed the richest chatoyance I had ever seen.

Another gem from Africa that has been around for decades is tiger's eye. Actually, it is the mineral crocidolite, a type of asbestos. This usually rich-brown lapidary gem shows a lovely iridescence due to the tightly grown fibers of crocidolite that are largely infused with iron oxide. If manganese gets into the coloring act, we call the rock "hawk's eye" for its blue color. Heat the stuff, and it may turn red due to alteration of iron oxide. Tiger's eye has been mined in Griqualand, South Africa, but export of this massive gem is now restricted.

A similar material from near Outja in Namibia is called pietersite. This is a crocidolite whose fibers are in a jumble rather than the orderly parallel arrangement seen in tiger's eye. The material is usually blue.

Also from Namibia have come a considerable number of super blue topaz crystals. These have been mined from pegmatite veins in the Klein Spitkopje mountain range. A recent visit there turned up nothing of note, but very fine pale-blue topazes were fairly common from this stark mountain region at one time.

Certainly the most commonly seen gem material from Africa, aside from diamonds, is the bright-green banded malachite that continues to flow from the huge copper deposits in Zaire. Known early on as the Roan-Antelope District, this area was developed in the early part of the 20th century. In the last 40 years, huge masses of this secondary copper carbonate gem have been mined and turned into everything from chess pieces

continued on next page

The Gems of Africa *from page 15*

to huge vases, even table tops and fireplaces. Wonderfully banded light- to dark-green cabochons are one of the common African gems used in inexpensive jewelry today.

Malachite isn't the only copper gem to come out of Africa. Small, crystallized pieces of bright-green dioptase from Tsumeb are often used for inexpensive necklaces. Wire wrapped or mounted in a silver bezel, these natural crystals are quite attractive.

Another African copper gem is cuprite, from a now-defunct copper mine at Onganja, Namibia. Cuprite is a simple copper oxide possessing a bright red color. When exposed to the air, it takes on a slight metallic sheen that is not unattractive. It is a common copper ore and does occur in clear, gemmy crystals that are usually quite small and not easily faceted. At Onganja, it was found in crystals that were exceptionally large for the species, easily suited for faceting. Some of these crystals measured over 2 inches across. All were coated with green malachite, but under that green coating rested gemmy, glass-clear, rich-red cuprite. Collectors usually will not put such fine crystals to the saw, but specimens that had been found damaged became excellent gem rough. Faceted cuprite gems over 75 carats were the result. They are very showy, but soft and easily surface-oxidized, so they are just a novelty.

We've only just reviewed a few of the facets of African gems so far. There remain such colorful beauties as elbaite, garnets, aquamarines, emeralds and zircons. One of the African gems you'll enjoy at the February 2002 TGMS Show is diamond. Certainly, diamonds comprise the largest single type of gem wealth produced by the Dark Continent. Rather than eulogize the major diamond finds, starting with the Cullinan, a brief comment on the first diamond finds might be of some interest.

Prior to the African finds, the earliest source of diamonds was India. That was followed by Brazil, the big producer until the mid-1800s. About the time Brazil dried up, finds were being made in the southern part of Africa. The first find was probably made in 1859, along a riverbank near Platberg. The find apparently was discounted or ignored. But in 1866, another find was made, one that actually stirred things up. The trials and travails of that first precious stone read like a storybook mystery. Was it a diamond or not? How was it found? Who finally identified it?

The find was made on a farm owned by the DeKalk family. One of the resident families there was named Jacobs, and included a young son, Erasmus. Erasmus had a Hottentot shepherd-boy playmate named Klonkie. It seems Klonkie saw an odd-looking stone and hit it toward Erasmus with a stick. Erasmus picked it up and took the "pebble" home. It ended up on the ground outside the Jacobs home, where it lay until a visiting part-time prospector and rockhound, Schalk van Niewkerk, thought the stone worth checking out. He showed the stone to friends and acquaintances. One fellow, James Wykeham, jokingly said it was a diamond, but it wasn't until Dr. Atherstone checked it out that it was recognized as such. This first verified gem came to be called the Eureka!

African diamonds were mined by alluvial methods until 1870, when the first of Africa's famous diamond pipes was found in the Orange Free State on the Koffiefontein farm. You know the rest of the story, a story that is still being told!

Of all the colored gems coming from Africa, perhaps the greatest variety of color comes from the garnet group. We've already described tsavorite, the vibrant, green grossular. Other gem garnets can be categorized in two general groups. One group are a mixture of pyrope and almandine, and sometimes spessartine. These tend to be red or a shade of red-orange. One shows a unique color change, a pyrope-spessartine or almandine garnet that shows an alexandrite color change from violet to green-blue. Some of the red/orange-red gems have been given local names like umbalite or Malaya, or have been named for color, such as rhodolite. The other type of garnet that is found in some abundance is grossular in a virtual rainbow of colors, from colorless to yellow to pink to brown.

Certainly, the exhibits you'll see at the February 2002 TGMS Show will far exceed what has been described here. Picture in your mind a 53-carat tsavorite or a 200-carat tanzanite. Or how about a gem display brought from Africa by the world renowned gem miner Campbell Bridges. And to give visitors something really special, Bridges' Feb. 13 lecture in the Tucson Convention Center will provide exciting insight into the frenzied world of gem prospecting and mining in Africa.

Don't forget to make reservations by phoning the TGMS reservation number, (520) 471-9749. Seating is very limited to so call early.

The intent here is simply to stimulate your interest in the vast array of wealth coming forth from Africa to be exhibited at this famous show. I know you will enjoy the breathtaking exhibits and offerings of some of the top gem/mineral dealers from around the world.

SHOP TALK

by William A. Kappele

Cutting Slabs and Preforms

After you have brought your brand-new diamond saw home and set it up in your garage or basement, you are faced with the decision of what to cut. If this is your first saw, you might not want to start with your most prized piece of gemstone. Grab a piece of "leaverite" instead, and get ready to make some cuts.

The first step is to fasten the rock securely in the saw vise. This sounds like a no-brainer, but believe me, it is possible to do it wrong. If rocks were all nicely formed cubes, this task would be simpler, but as we all know, most are shaped more like the Matterhorn.

When you decide just where you want to make your first cut, see how the rock will fit in the vise. If it tends to slip when you tighten it down, you may have to make a freehand cut to create a flat spot for the vise jaw to grip. If your vise's jaws are not lined with wood, I strongly recommend that you add some. Just scrap pine or something similar will work fine. The wood is soft enough to let the sharp spots on the rock dig in and get a better grip, but strong enough to prevent slipping. When you do the final tightening, to try to wiggle the rock before you begin the cut. Nothing will spoil your day more than having a rock come loose and turn your brand-new blade into a big, diamond-encrusted coaster.

The next hurdle to get over is starting the cut. Remember that you have a Matterhorn and not a cube. If you try to start the cut on a slope, the blade is liable to be deflected down the slope. If the blade is allowed to continue, it will be dished. How long it runs in this direction will determine whether you have a reparable dish or a diamond-rimmed funnel. To be sure of getting a square start, you may have to cut a small flat on the slope. Sometimes, you will be lucky enough to be able to reorient the stone in the vise. Even with a good flat for a start, it is wise to begin the cut by hand and to feed the rock in very slowly until you are sure it is cutting straight. When you are comfortable cutting the leaverite, it's time to get out the good stuff and cut some slabs.

As the blade gets closer and closer to the vise, you discover another lapidary headache. A significant chunk of your prize rock is too far into the vise to be cut. This is usually referred to as the "heel," and it is often tossed into the junk pile. This is too bad, since it is fairly simple to get a few more slabs out of it. The trick is to adhere the flat side (the part just cut) to a squared-off piece of wood. Be sure the face of the stone is flat. There is usually a ridge at the bottom where the last slab broke off at the end of the cut. Clean the face of the heel and stick it to the wood block with your favorite adhesive.

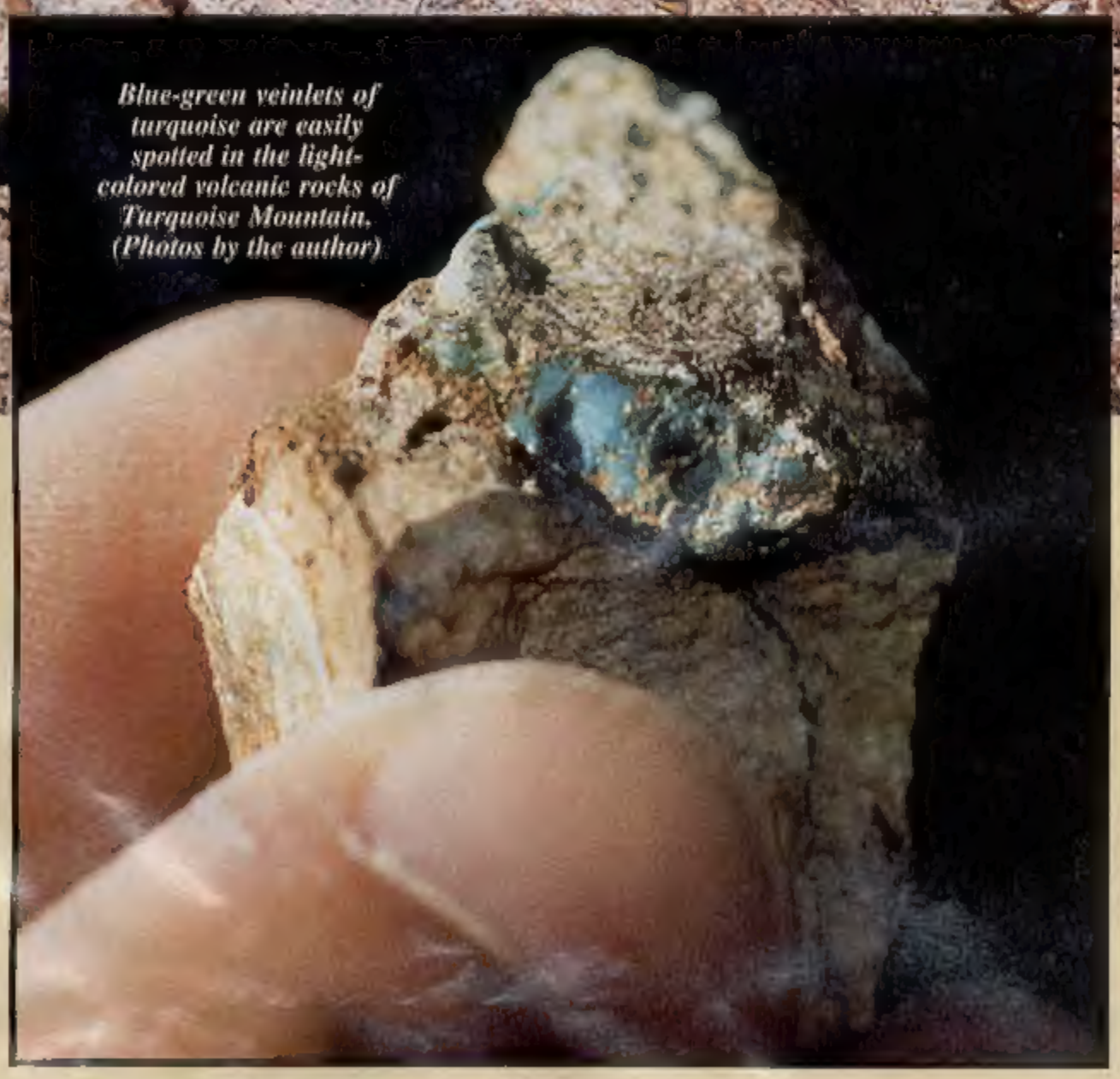
After wringing out every possible slab from your treasure, it's time to cut some cabochon preforms. Use a template to help find the best-looking spot on your slab, then draw the shape of the cab on the slab with a sharpened aluminum or brass rod.

With the cab shape marked on your slab, the next step is to cut it out as close to the line as you can. This trimmed slab is called a preform. Cut the corners off the preform as close to the line as you can. To save a lot of grinding, use the old trick of cutting notches just short of your line all around the perimeter. This allows you to cut from notch to notch in a straight line, but still approximate the curve of the cab.

Pat yourself on the back. You are ready to head for the grinder.

Please feel free to contact me if you have a suggestion or comment about this or any of my Shop Talk columns. My e-mail is quappelle3@home.com, or write to me at 25231 Pericia Dr., Mission Viejo, CA 92691.

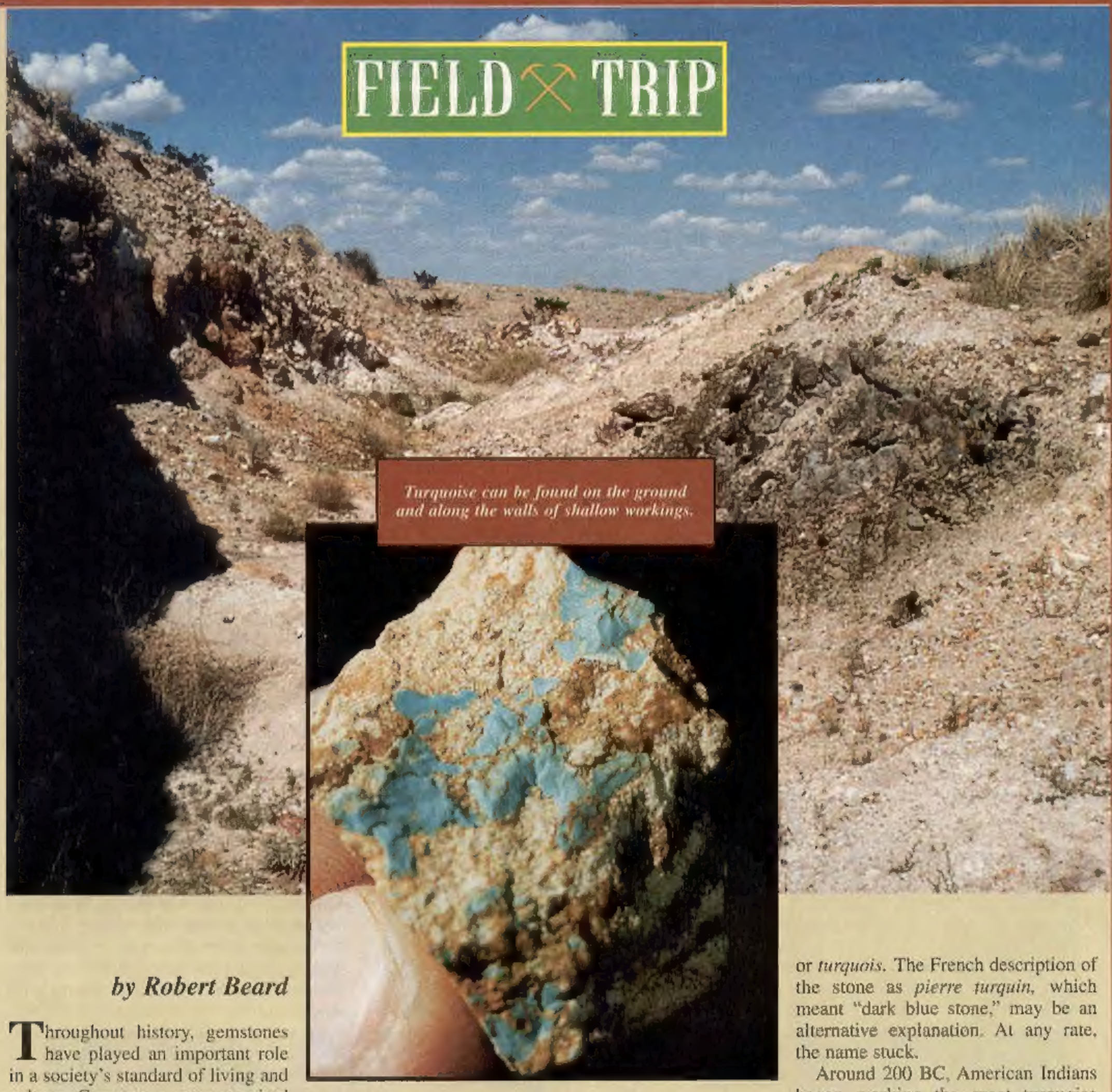
Little Hatchet Mountains Turquoise



Blue-green veinlets of turquoise are easily spotted in the light-colored volcanic rocks of Turquoise Mountain. (Photos by the author)

Run to the Border for a Wealth of Collecting Opportunities

FIELD TRIP



Turquoise can be found on the ground and along the walls of shallow workings.

by Robert Beard

Throughout history, gemstones have played an important role in a society's standard of living and culture. Gemstones were acquired either from local deposits or through conquest. Placer deposits provided ancient peoples with rubies, sapphires and diamonds, but lode deposits of gemstones remained largely unexploited for most of antiquity. Turquoise, however, was an exception.

Turquoise is one of the oldest-known gemstones, and its occurrence near the surface made it accessible to those with the crudest of mining tools. Only its distinct blue color makes it a gemstone, as it does not form crystals, and it is not very hard when compared to most gems. This color is so unique that the name turquoise is used to describe almost any color that resembles it.

Rather than memorize the chemical formula for turquoise [$CuAl_6(PO_4)_4(OH)\cdot 4H_2O$] it is easier to describe this gemstone as a hydrated phosphate of copper and aluminum. It is formed by the percolation of rainwater or groundwater through aluminous rock in the presence of copper. It is often found as a secondary mineral in copper deposits, and is most often found in arid, semiarid or desert environments.

The earliest turquoise mining areas are in the Alimerai Mountains in Iran (formerly Persia) and the Sinai Peninsula in Egypt. These deposits were worked thousands of years ago, and the Sinai mines are among the oldest known mines in the world. Turquoise deposits in arid areas were undoubtedly easier to identify, as there would have been less vegetation to obscure the turquoise. When the stone was introduced to Europe, it came through Turkey, which was often believed to be the source of the turquoise. "Turkish" in the Frank or French language of that time was *turquoise* or *turquois*. The French description of the stone as *pierre turquin*, which meant "dark blue stone," may be an alternative explanation. At any rate, the name stuck.

Around 200 BC, American Indians began working the great turquoise deposits of the southwestern United States. Turquoise was mined in what later became Arizona, California, Colorado, Nevada and New Mexico. In the late 19th century, when many metal mines in the Southwest were becoming exhausted, miners began to recognize the potential for mining turquoise.

As with any gemstone, the marketing of turquoise was everything. In the 1880s, Persian turquoise had the qualities that jewelers and the public wanted. It was a distinct sky blue with no hint of green, was hard, and had no impurities. "Impurities" in this context referred to matrix, which was often limonite that filled fractures in the turquoise. The turquoise of the southwestern United States was said to be prone to fading, and was of little value.

continued on next page

Little Hatchet Mountains Turquoise *from page 21*

That all changed due to the Azure Turquoise Co. of New York. This company organized in 1891, developed the Azure Mine in the Burro Mountains about 10 miles southwest of Silver City, New Mexico. The stones in this deposit were a robin's egg blue, which is blue with a slight hint of green. The company guaranteed that its stones would not fade and become greener, and in 1893 began engraving a small circle on the back of its stones as a company trademark. Other companies soon followed suit, and this solved the marketing issues with fading gem color change.

The New York jewelers that controlled the turquoise mines and the finished products were extremely successful in marketing turquoise jewelry, and the value of turquoise became greater than that of gold by weight. A boom existed, and several companies operated turquoise mines in the Southwest. But like all booms, there was a bust, and the great silver crash of 1893, combined with excess turquoise on the market, resulted in a dramatic decrease in U.S. production in 1894.

But although production decreased, there was still an abundant supply of mined turquoise. Without an increase in the investment value of turquoise as had been sold, the public rapidly began to lose interest in its value as a gem, which led to further price collapses. Mining continued at many of the turquoise mines, but by 1909 nearly all of them had closed. The collapse of prices due to the gemstone's decreased status effectively led to the demise of the American turquoise mining industry after 1910.

Today turquoise is still mined in Arizona, California, Colorado and Nevada. Turquoise is now generally treated to retain its hardness, and this has dramatically increased the availability of turquoise for jewelry. Ironically, the New Mexico deposits, which were among the oldest and best-known deposits, are no longer worked commercially. New Mexico turquoise was the first to displace Persian turquoise in the market, and the impact on state history is best shown by the fact that turquoise is the state mineral of New Mexico. The most famous turquoise districts in New Mexico are at Cerrillos, south of Santa Fe, and the Burro Mountains, south of Silver City. Deposits are also known in the Jarilla Hills in Otero County, the Guadalupe Mountains in Eddy County, and in the Little Hatchet Mountains in Grant County.

My first exposure to turquoise collecting in New Mexico was a direct result of the routine checking of place names when reviewing maps. While researching USGS topographic quadrangles for a collecting trip I was planning to the Apache No. 2 Mining District, southeast of Hachita, I spotted a very intriguing name on the Playas Peak, New Mexico, quadrangle. This was Turquoise Mountain, which is located west of Hachita in the Little Hatchet Mountains. The area was dotted with Xs marking prospect pits, arrows indicating adits, and squares denoting mining shafts. I had not originally planned to look for turquoise, but Turquoise Mountain really piqued my interest. My hopes were raised even more when I learned it was Bureau of Land Management (BLM) land, which indicated that it would likely be accessible for collecting.

Indians first worked the turquoise deposits at Turquoise Mountain hundreds of years ago. In the 1880s, mines in the Eureka Mining District, which surrounds the area of Turquoise Mountain, were worked for gold, silver and copper. None of these deposits proved to be of great economic importance, and in 1885 miners began working the district for turquoise. Mining lasted until 1888 and was restarted in 1892, but with little result. In 1908, extensive mining was begun, but it only lasted a few years. Fine sky blue material was reported to have come from a number of claims.

The turquoise deposits in the Little Hatchet Mountains have reportedly produced some large pieces of turquoise. John Sinkankas, in *Gemstones of North America*, Vol. III (Geoscience Press, Tucson, Arizona) described a 160-pound piece that was extracted in 1926 "from a mine in the Hachita Mountains." This piece was carved into a scene depicting a pueblo and its occupants and was exhibited at the Tucson Gem & Mineral Show in 2001 by Freed and's Jewelry of Tucson. The piece weighed 121 pounds after carving, and was "considered to be the largest in the world" according to information from the 2001 Tucson Show Web site. The asking price was $750,000.

Turquoise occurs in altered rocks along the borders of a hydrothermally altered monzonite stock and andesite breccia on Turquoise Mountain

Geologic mapping by Robert Zeller in "Geology of the Little Hachet Mountains, Hidalgo and Grant Counties, New Mexico" (Bulletin 96 of the New Mexico Bureau of Mines and Mineral Resources) indicates that Turquoise Mountain consists of a hydrothermally altered monzonite stock and andesite breccia of the Hidalgo Volcanics. The Hidalgo Volcanics are believed to be early Tertiary in age, indicating that the monzonite stock may also be early Tertiary. Where exposed, the stock is generally iron stained due to the abundance of disseminated pyrite in the unweathered rock. Much of the rock has been altered to clay minerals; this is immediately apparent from the fine grained, white character of the rock. Turquoise occurs in altered rocks along the borders of the stock.

Zeller was an excellent geologist, and he devoted much of his career to understanding the geology of this area of New Mexico. Unfortunately, he was killed in a plane crash in 1970. He was at the peak of his career at the time of his death, and he had much more work left to do. Much of our understanding of the geology of southwest New Mexico is based on Dr. Zeller's work.

An article by Xan Hughus Carson in the April 1975 issue of *Rockhound* magazine (John H. Latham Productions Inc., Conroe, Texas) described the area in detail from a collector's standpoint. While Turquoise Mountain has been the focus of turquoise activity in the district, showings that are not profitable for large-scale commercial mining, but are attractive to collectors, surround the mountain.

The Azure Mine, which is not to be confused with the Azure Mine in the Burro Mountains Turquoise District, is located on top of Turquoise Mountain. This mine was reported to have produced high grade material. The Cameo Mine was reported to be about one mile northwest of the northeast end of Turquoise Mountain and was developed via a vertical shaft. The material is reported to be similar to that of the Azure Mine, and is reportedly one of the oldest mines in the area, based on the number of stone tools found nearby. The Gamlee Mine was about one-half mile southwest of Turquoise Mountain, and was worked by a large pit. This mine has reportedly produced from two prominent veins.

The Aztec Mine, named because of its prehistoric workings, is about one and one-half miles southwest of Turquoise Mountain. This mine was worked by an adit, and the turquoise occurs in seams, with nuggets scattered throughout the rock. It is soft and pale, and sometimes fades under exposure to weather and sunlight. Darker blue turquoise is reported to occur in the American Turquoise Mine, which is a few hundred yards west of the Cameo Mine. This claim has been worked from both an open pit and shafts, and its turquoise is reported to be quite hard and predominantly pure. Carson reported that these mines and most of the other claims in the area are patented, but that collectors would encounter no entry problems as long as property rights are respected.

My family and I had the opportunity to visit Turquoise Mountain during the summer of 2000. We got to the area by taking Interstate 10, then state Highway 146 south to Hachita. From there state Highway 9 took us to the roads that lead to Turquoise Mountain. I-10 is the main highway through the area and provides a rapid way to access the various mining districts in the region. Since the area appeared to be only a short distance from I-10, my wife, Rosalina, and our two children came along. Rosalina was interested in getting some turquoise, and she was very excited about the trip. Much to my dismay, her enthusiasm began to wane after we had been in the car for about three hours. We were coming from the El Paso area, and it was a longer drive than I thought.

Her diminished enthusiasm soon gave way to real concern, however, when we left the pavement and she saw the road to Turquoise Mountain. We had a four-wheel-drive Dodge Durango, with air conditioning and lots of water, but we were still out in the middle of nowhere with two little kids. It was about 100 degrees F, and the sun was unbearably bright. Any car breakdowns or tires stuck in the sand could prove disastrous.

She was also scared of encountering illegal aliens crossing the border from Mexico. I thought this was ridiculous. Who in their right mind would attempt to cross these mountains, in this desert? It was like an oven, outside, and there were no good places for anyone to hide. Despite my assurances, Rosalina was not convinced.

We passed the ghost town of Old Hachita on the way to Turquoise Mountain. This is a very striking ghost town, as many of the buildings are still standing. There are also headframes and mine dumps, but none of the dumps held any interesting minerals. The dumps appeared to be mainly limonite stained, fine grained, altered volcanic rocks. The shafts near the headframes are still open, and one has to be extremely careful when exploring this area.

The road that passes Old Hachita leads right up to the base of Turquoise Mountain. We parked the truck and walked up to the summit, which is a very short hike. We watched very carefully for snakes, but the sun and heat apparently kept them in their dens.

I was a little disappointed at first, as I expected to see turquoise right away. Rosalina, however, found a nice piece of greenish turquoise lying on the ground fairly quickly. At the top of the mountain we had an excellent panoramic view of the entire district. Although we were only about eight miles from Hachita, the area was extremely remote, and extremely quiet.

continued on next page

It was too quiet for Rosalina. She was convinced that we were in great danger of being ambushed by illegal aliens, so we headed back down the mountain. Fortunately, we came across several large cuts that had been made on the sides of Turquoise Mountain as we walked down. Many of the rocks were white to brown, and thin bands of sky-blue to green turquoise were often present. Despite the urgency to leave, we took the time to break open several of these pieces. I only had a hammer and a chisel, and thought that a large breaker bar would have been useful. Many of the pieces that we broke had nice veinlets of turquoise, but the largest veins I saw were about ¼ inch thick. It took some searching to find good pieces, but they were there.

The best areas seemed to be where others had worked. I found that by carefully observing the white, altered volcanic rocks, I could often seen a hint of blue or green. This was the place to break open the rock, as that small indication of color often expanded into a section of larger vein. This was very consistent with the geologic description of the mineralization that was given in Bulletin 96. Areas with veinlets on the surface warranted deeper exploration using a breaker bar or other tool, as collecting in the district had undoubtedly removed the bulk of the loose turquoise on the surface.

At the time of my visit, I did not have access to Mr. Carson's article in *Rockhound*, so I was not aware that there were other turquoise deposits in the area, but even if I had had a copy, there was no way I would have been allowed to spend any more time prospecting, since Rosalina was now ready to leave. We got in our vehicle and immediately drove back to the highway.

Given the remoteness of the site, and obscurity of the Carson article, I thought that it was quite likely that most collectors came to the Turquoise Mountain area only, and did not get to thoroughly explore the area. If you were to look for the deposits described in the *Rockhound* article using both a topographic map and the geologic map from Bulletin 96, you might be able to find some significant pieces of turquoise. We did not see any indications of claim stakes or other restrictions to casual collecting in the area of Turquoise Mountain, and presumably this is also the case in the surrounding deposits.

After we got back onto state Highway 146, we passed a vehicle on the eastern side of the road. Several men in combat fatigues were along the side of the road. We assumed they were Border Patrol agents. A little farther along, we stopped when we saw a couple of tarantulas crossing the highway. Tarantulas are often so big that they are easy to spot even when going 65 mph. We pulled over and got a good look at them.

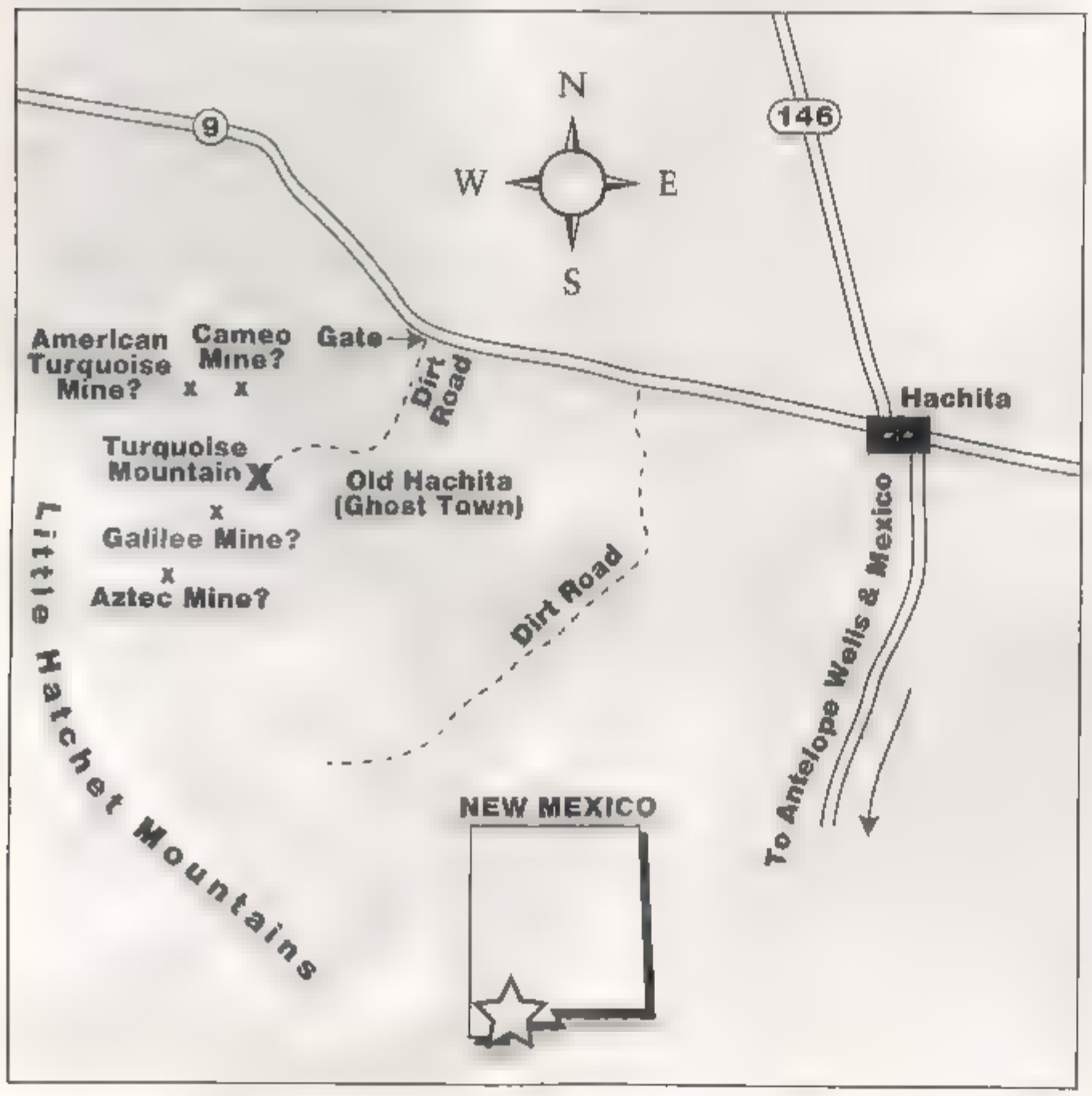
Pulling our vehicle to the side of the road must have raised some eyebrows with the men we passed, as we were soon pursued by a large Border Patrol vehicle. When we turned east on I-10, the large vehicle was still on our tail, and soon put on its revolving light. We pulled over right away.

The uniformed driver walked up to our vehicle and asked what we had been doing. Apparently by just being in the area we were suspicious, and pulling over to look at the tarantulas was even more unusual. He was extremely polite, and accepted our explanation that we were only out looking for minerals.

He explained that illegal aliens were a major problem in the area. They often crossed the desert, especially at night. He said that people like us normally were not in danger from them, and that if we made our presence known by making lots of noise, any illegals nearby would generally give us a wide berth. However, if we came across a large group, or deliberately put ourselves in danger by camping in remote areas and not being vigilant, we could have some problems. He said that if we saw anything unusual to report it to a Border Patrol agent right away. Having encountered the Border Patrol as we did, it did not appear that it would be difficult to find an agent, especially if you went close to town.

When I was working in southwest New Mexico in the early 1980s as a geologist, I never had any encounters with the Border Patrol, and none of my colleagues ever discussed dealing with illegal aliens as a potential field issue. In the 2000s it is apparently a very significant field issue, especially with the related problems of drug smuggling as well as smuggling aliens. With the further efforts to seal our borders to address terrorists crossing, we can only expect more Border Patrol activity in the area. If anything this is likely to reduce the threat from illegals to mineral hunters, but people entering these areas for recreational purposes have to be aware of the situation, be vigilant, and cooperate with the Border Patrol as necessary. At this time, I do not hesitate to collect near the border, but make certain that I am aware of my surroundings and any unusual activity at all times.

Despite its remoteness and the Border Patrol activity, the deposits at Turquoise Mountain are well worth visiting. You are practically guaranteed to come back with some turquoise, even if you just collect on Turquoise Mountain itself. If you have the time to spend in the area, and are equipped to do so, prospecting for the other turquoise deposits in the area around Turquoise Mountain could also prove productive. New Mexico turquoise will probably never be produced again commercially, but the deposits around Turquoise Mountain and the Little Hatchet Mountains will likely produce turquoise for the collector for many years to come.



FIELD TRIP

THE MORDEN EXPERIENCE

Collecting Vertebrate Fossils (Legally)

by Kenneth H. Rohn

Being a member of the Mineral Society of Manitoba has its privileges. One of these is the highly informative newsletter we receive each month. Of course, living in the United States doesn't allow me to attend meetings at the university in Winnipeg like I should, but I'm kept abreast of the activities and highlights of these meetings through the newsletter.

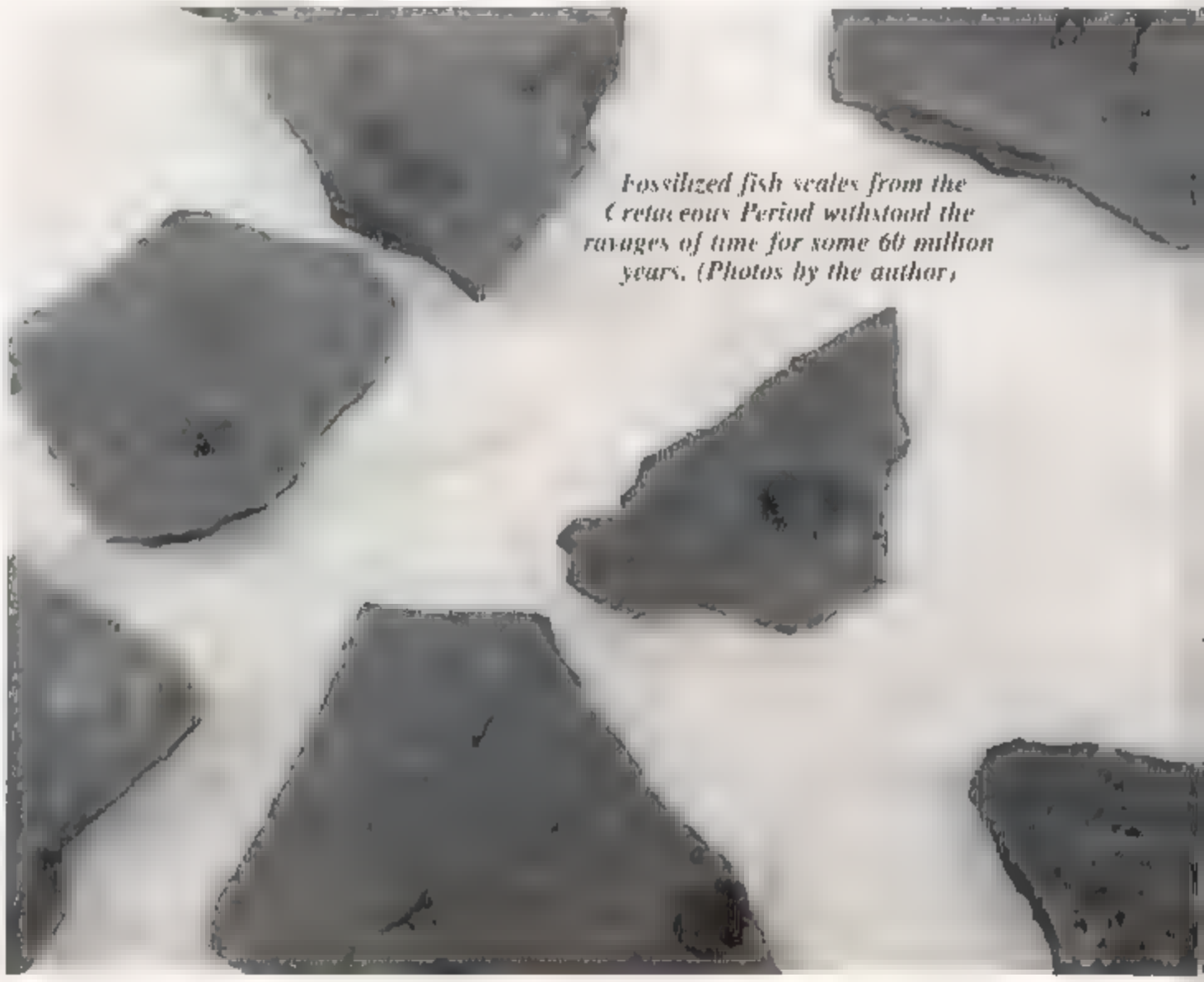
In a recent issue, I learned of the Morden, Manitoba, trip to be conducted by Field Trip Chairman Jack Bauer. This trip would not only give me the opportunity to visit fellow members, but the chance to have a hands-on paleontological experience at one or more of the many collecting sites in the area.

This particular trip was arranged for the society members by the curator of the Morden District Museum, Mike Waddell, and his associates at Paleo Tours, a field trip organization associated with the museum. We would have permission to enter property owned by Pembina Mountain Clays, a bentonite mining and processing firm. So it was with this exciting prospect in mind that I traveled to Winnipeg, that I would have the opportunity to excavate prehistoric reptile remains firsthand.

My base camp would be in the Conestoga Campground on Perimeter Highway 100 South in Winnipeg. Four vehicles left Winnipeg for the trip to Morden, located 103 kilometers (80 miles) to the southwest of the city via provincial Highway 3. We were to meet more members in Morden. Fellow member and old friend Mavis Bedford rode with me in my pickup camper to the museum.

Upon arrival, Mike had us gather around while he explained the nature of our field trip and what we might expect to find at these sites. We would travel some 16 kilometers (10 miles) by shuttle vans to the sites. We would be searching in areas practically on top of the Manitoba Escarpment.

This escarpment is the remains of what was once the ancient shoreline of Lake Agassiz. The lake was formed many millions of years after the Mid-continental Seaway, a vast warm inland sea, had literally dried up, causing the death and burial of all those sea creatures that lived there by eons of sedimentary deposition. Today, this ancient shoreline is seen as a high ridge of land running in a northwest to southeast direction. Fossils of that long ago period of the earth's history can be found in exposed areas of the "chalk" (limestone) ridge. Our goal was to collect specimens of selenite crystals in road cuts and eroded areas, and then travel to an abandoned bentonite mine in the immediate area. Thanks to the cooperation of the mine property owners, we would be allowed access to the pit. It would prove to be an exciting adventure.



Fossilized fish scales from the Cretaceous Period withstood the ravages of time for some 60 million years. (Photos by the author)

The Manitoba Escarpment

Millions of years in the past, an immense sea covered much of what is now dry land on the North American continent. In that sea lived the strange vertebrates that will be discussed in the following paragraphs.

During the Cretaceous Period of the Mesozoic Era, from approximately 125 million to 65 million years ago, this area of Manitoba, today a vast prairie, was once part of what is known as the Mid Continent Seaway. I have touched on this seaway briefly in other articles, particularly Seascapes and Fossils (September 2000 *Rock & Gem*). This vast expanse of water was 1,000 miles wide and stretched from the Manitoba Escarpment all the way to Mexico. It was an ideal and stable environment for millions of years, and home to myriad sea creatures long since extinct. During that time, there lived a vicious and terrifying marine reptile, the mosasaur. It was a carnivore that often grew to an awesome length of 50 feet. It had a voracious appetite and consumed large numbers of fish and other reptiles weaker and smaller than itself.

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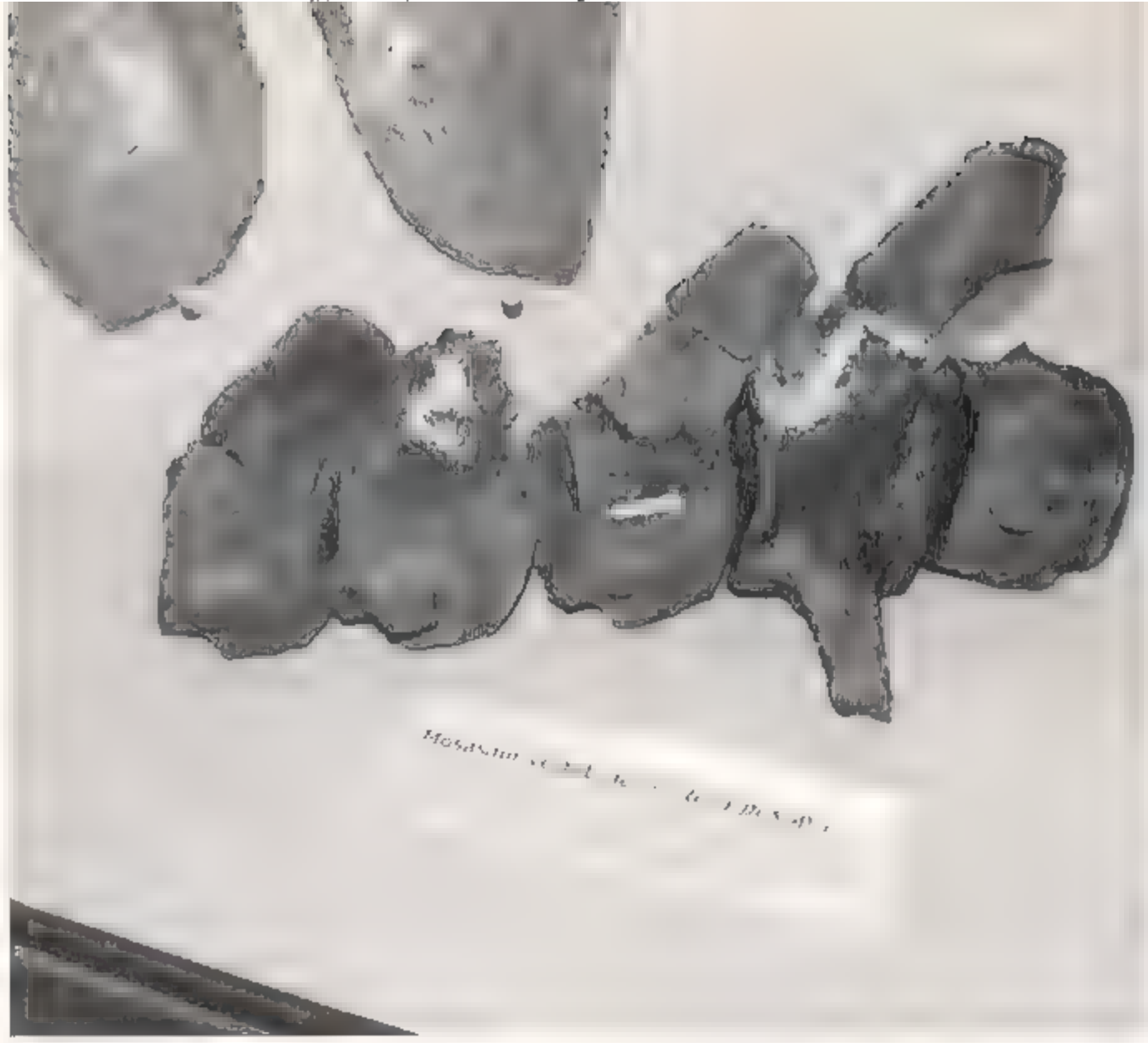
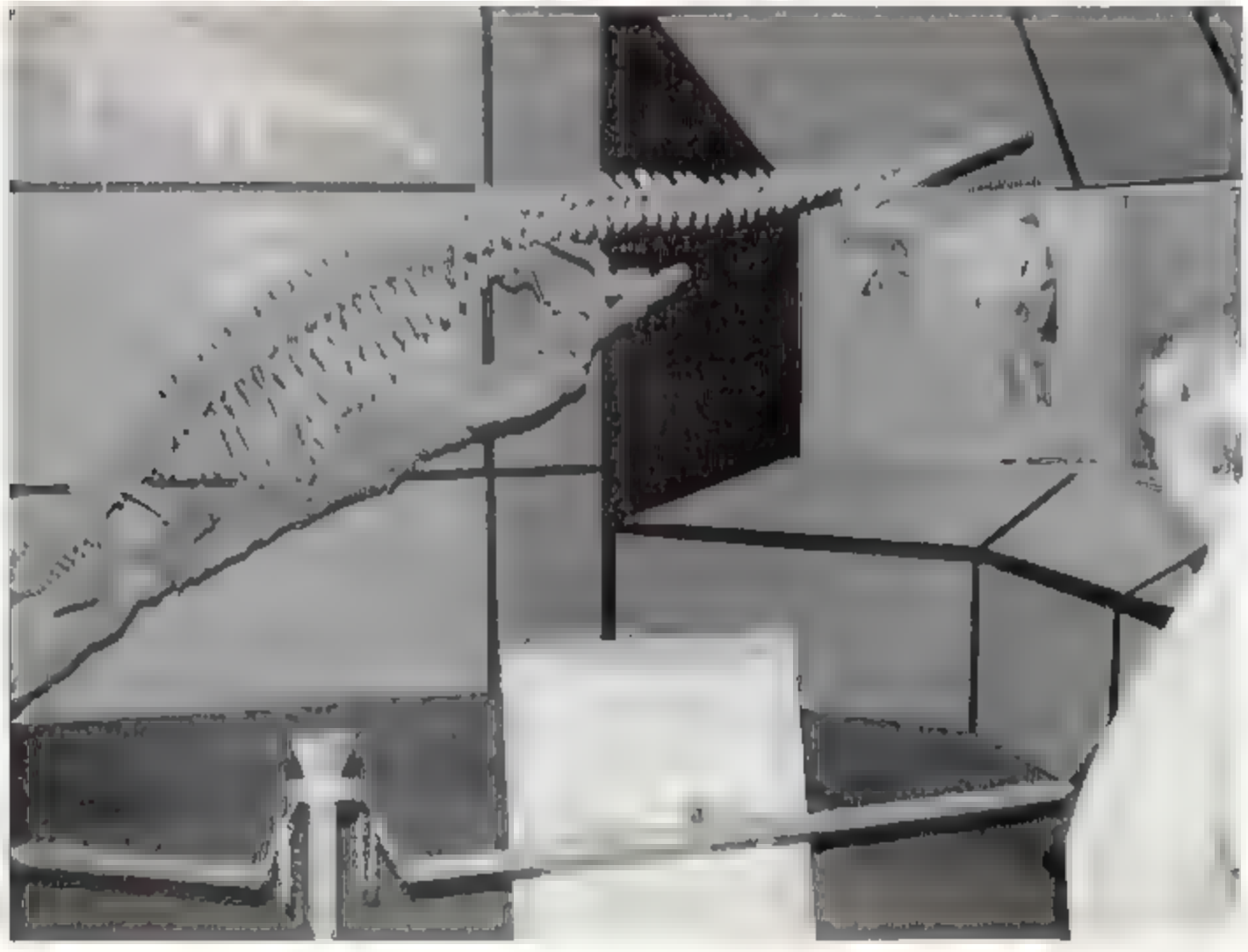
A field trip participant found this fossilized shark tooth at the abandoned bentonite mine west of Morden, Manitoba.



Vertebrae of the marine predator mosasaur are often discovered incomplete. This specimen is part of the extensive display at the Morden District Museum.

The plesiosaur, a creature similar to the mosasaur, thrived in the waters of the Mid-Continent Seaway, which covered much of central North America during the Cretaceous Period.



There are three types of this species that closely resemble one another. They are elasmosaurus, platecarpus and tylosaurus. The slight differences in these three types are the size of their flippers, variations in rib-cage size, and minute variations in their skulls. The platecarpus, for instance, had a much heavier spinal column than either elasmosaurus or tylosaurus. Its flippers were somewhat larger than the other two, but it was much the same in all other respects. This lizard had scales and although it resembled our contemporary alligator, the monitor lizard of the Far East is what could be called its nearest living relative. The monitor is one very hideous-looking creature.

The mosasaur's jaws were designed for capturing and swallowing large prey. They could not only open their jaws extremely wide, they could also, by means of a 'joint' in the mandibles, expand their jaws outward to capture even larger prey when the need arose. By all appearances, that need was quite often. They had a set of razor-sharp teeth, along with a group of back-slanting pterygoid teeth located in the palate that could help hold its victims. Its main diet appears to have been fish, of which there were multitudes at that time. Evidence also suggests that they may have been cannibalistic. It is believed that mosasaurs bore live young while in the water because of their large size and their lack of legs, which would have made it difficult to crawl out of the water and onto dry land in order to lay eggs.

Another reptile that lived at the time was the plesiosaur, about which scientists have arrived at another assumption. It is believed that this creature was not as agile as the mosasaur. Its clumsiness was due to a smaller body, weaker and somewhat less flexible tail, and less maneuverable flippers. It is assumed that the plesiosaur bore live young because of similar characteristics to those of the mosasaur. There were two distinct types of this creature: the very long-necked elasmosaurus and the shorter-necked pliosaur (dolichorhynchops). Their means of propulsion was large flippers, much like those of today's sea turtles. The elasmosaurus had as many as 70 vertebrae in its neck alone and a small head. The mouth held an abundance of very sharp teeth. It is quite probable that they caught their prey near or on the surface. The short-necked pliosaur had approximately 20 vertebrae in its neck. Although these two types were very closely related, their appearance is drastically different. The elasmosaurus had a much smaller body and flippers than the stubby and bulky pliosaur. The latter had a more powerful bone structure throughout.

Plesiosaurs were more numerous in the Jurassic Period, 150 million to 125 million years ago. Their numbers dropped off during the beginning of the Cretaceous. This is when mosasaurs became numerous and, one could say, dominated that vast inland sea. Plesiosaur fossils are much more rare in this area than the mosasaurs.

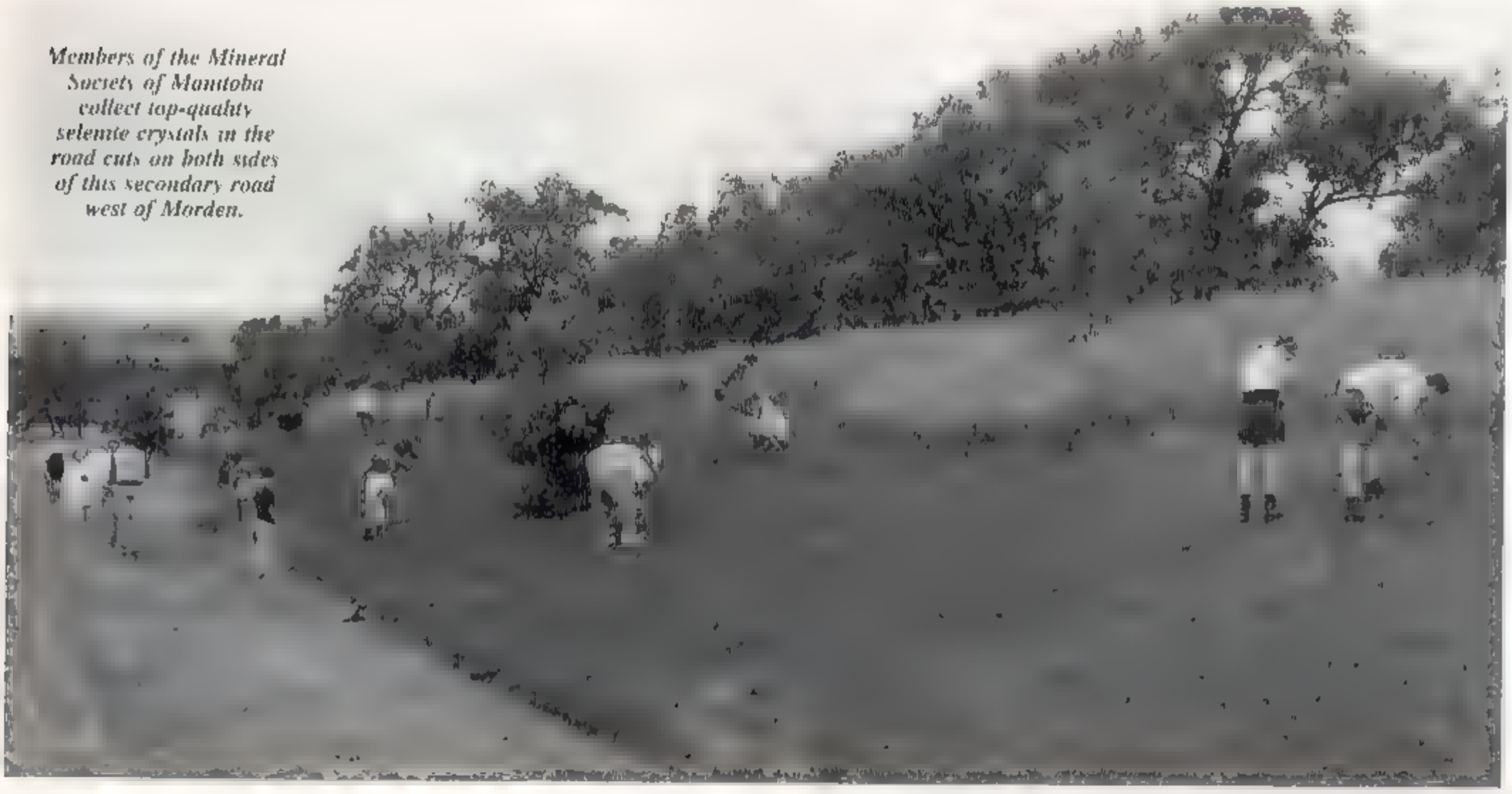
Among the wealth of vertebrates that lived here those millions of years ago, the giant turtle archelon is a most impressive fossil find. During the late 1930s, more than 'key in a bentonite mining operation, a huge archelon measuring close to 10 feet in length was discovered near Morden. Its remains were destroyed because nobody at that time knew the art of recovering and preserving them. This turtle, it is assumed, was quite agile for its size and could catch its prey with little difficulty. It resembled our modern-day sea turtles to a remarkable degree. Although it is believed that it could not retract its head into the shell, it did have heavy armor protecting it in a series of scutes (bony plates).

Among the many other denizens that lived in this warm inland sea was the portheus, a large fish related to the tarpon. It had an intimidating set of teeth that would be the envy of any modern day tarpon. There also was the bulldog tarpon, xiphactinus molossus. It had a blunt head shaped much like a bulldog's. It often reached a length of 15 feet and could weigh as much as 600 pounds.

There were many species of fish in the Cretaceous Period but few intact fossils are ever found. Often, teeth and vertebrae are the only means of identifying these fish.

Among the fossils to be collected along the escarpment ridges are the remains of the most primitive of fish, sharks. They appear in the scientific fossil record close to 400 million years ago. Shark skeletons have no bones, being composed of cartilage. That is why the vast majority of fossil remains are teeth and, occasionally, ossified vertebrae. Those ancient sharks bore a remarkable resemblance to modern ones, although they were, as a rule, much smaller.

When the mosasaurs and plesiosaurs began to die out near the end of the Cretaceous Period, sharks grew much larg-



Members of the Mineral Society of Manitoba collect top-quality selenite crystals in the road cuts on both sides of this secondary road west of Morden.

er and soon dominated the world's oceans. The carcharodon, a forerunner of the great white shark, often reached a length of 50 feet or more, and had jaws that, when open, reached a span of 6 feet, with 8-inch teeth!

Birds, although quite primitive, lived during the Cretaceous Period. Their remains, however, are rare and often only fragmentary in nature. The ichthyornis (fish bird) could fly and was armed with powerful wings and backward-curved teeth in both its upper and lower bill. The upper teeth did not quite reach the end of the beak. The jaws of this bird have often been confused with the remains of small mosasaurs, due to a vague resemblance to one another. The various species of this bird stood from 6 to 9 inches high.

One other bird, the little-known hesperornis, had flightless wings and looked like the loons of today, but was much larger. It is also believed that it might have given birth to live young, but this hypothesis has not been proven to date. This was a bird that spent much of its life in the water, paddling from its large feet and flat sternum.

In the United States, those who are not members of the scientific community are prohibited from collecting vertebrate fossils. Scientists can collect and categorize them for future study, and the layman can participate in a dig, under strict supervision and guidance. There are private fee digging areas scattered about the Western United States where private individuals may dig for vertebrates and, unless they are extremely rare finds, keep what is found. In Alberta, on the other hand, the layman is not allowed to collect any vertebrate fossils. I'm referring to the Drumheller Dinosaur beds southwest of Edmonton.

As for Manitoba, I could find no documentation prohibiting the layman from collecting and keeping vertebrate fossils and/or fragments. After curator Waddell gave his interesting talk, we proceeded in two vans, plus some private autos, to the collecting sites. I was in the first van, sitting behind Mike and Jack. Jack and I were engrossed in a conversation about the wonderful opportunities for fossil collecting along the Manitoba Escarpment.

This trip was conducted under the supervision of the executive members of the Morden, Manitoba, museum and Paleo Tours. For a small fee, we were able to enter mining company property west of the city. However, there is no reason anyone cannot strike out on their own and hunt for fossils in several places along the escarpment, going as far as the town of Miami, 42 kilometers (26 miles) northwest of Morden, and south toward the border. It would also pay to check out all secondary roads leading directly to and right on the top of the escarpment for eroded areas. The road cuts themselves have good potential. Of course, one must seek and ask permission to hunt on private property, whether it is owned by individuals or mining companies. We must use common sense and follow the rules of good conduct, no matter where we may be.

The escarpment can be seen as a continuous, high ridge in the blue haze of distance on the horizon, as one drives north on provincial Highway 3 after leaving Morden. The van stopped several miles west of Morden on a secondary road. I couldn't procure a detailed map of this area, but inquiries locally will get you going in the right direction. Morden is a small community and it shouldn't be difficult to locate roads leading to the escarpment.

Selenite and Skeletons

As I got out of the van, I could see sparkling selenite crystals in the dark-gray crumbly earth of the cuts on both sides of the road. Crystals were scattered everywhere. They were even sparkling up at us from the surface of the road. I collected several doubly terminated crystals that are quite clear with some black inclusions in places. One is a perfectly shaped diagonal rectangle exactly 2 inches long, ¾ inch wide and ¼ inch thick. The largest one I found is just a bit over 2 inches long, with the same diagonal, doubly terminated shape. It has the silvery luster and chatoyancy of satin spar.

Selenite is a translucent, crystallized member of the gypsum family. Gypsum is composed of calcium sulfate dihydrate. It has a hardness of Mohs 2, with a specific gravity of 2.317 for the solid crystals and much less for the porous, massive specimens. It is easily scratched with a fingernail, and therefore has its limitations for any form of jewelry. It is, however, a most important mineral for industry. The vast majority of us have it covering the inside walls of our homes in the form of plaster. Gypsum, a sedimentary rock, is deposited from evaporating seawater. When crystallized in the monoclinic system, it is known as selenite.

A few more miles along the secondary road brought us to an abandoned bentonite mine. (Inquire locally about this abandoned mine pit.) It was cut in a deep "V" shape perpendicular to the road, and was at least 50 feet deep at the deepest point. It is 30 or more feet wide and gradually narrows down as the cut nears the road right of way. The group gathered at the pit edge to listen to Mike and his associates explain the nature of the various layers of earth and what could be found there. They pointed out the thin, lighter-colored seams of bentonite sandwiched between much thicker layers of gray clay, with various layers of other colorful minerals showing in the mine cut. I noticed a flagged area high up on the bank. This is where some mosasaur ribs had been exposed by erosion and had not been thoroughly examined at that time. At some later date, the fossils will be carefully excavated and placed in a "field

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jacket" composed of burlap soaked in plaster of Paris. Strangely enough, the very material that helps to protect and temporarily preserve the fossils for their journey to the museum is composed of gypsum, a mineral that is quite common here.

If paleontologists find that the bones are too fragile to stand transportation, they will apply a chemical hardener called glyptal. This does not detract from the original appearance of the fossils. It only helps to strengthen the bone structure. A splendid treatise on fossil preparation is "A Fossil Preparator's Primer," by Peter Larson (September 2001 *Rock & Gem*). I had the good fortune to meet Pete in Hot City, South Dakota, in the summer of 1995. He joined our society members on a memorable field trip to the badlands near the town of Wasta.

While we were at the abandoned bentonite pit that day, we searched for fossils in the pit and along the banks. One man next to me picked up a magnificent shark tooth. I found a fragment of a bone, perhaps a vertebra. It has the typical structure, with the pores quite distinguishable. I also tried to get a photo of the exposed mosasaur ribs in the mine wall, but it was in such a precarious place, I gave up. I managed to get within a few yards of them before I began to lose my footing and slide in the loose clay.

Vertebrate Fossil Collecting Opportunity

A most interesting bit of news came to me from one of my associates while researching this article. It has the potential for an outstanding side trip while in the Winnipeg area.

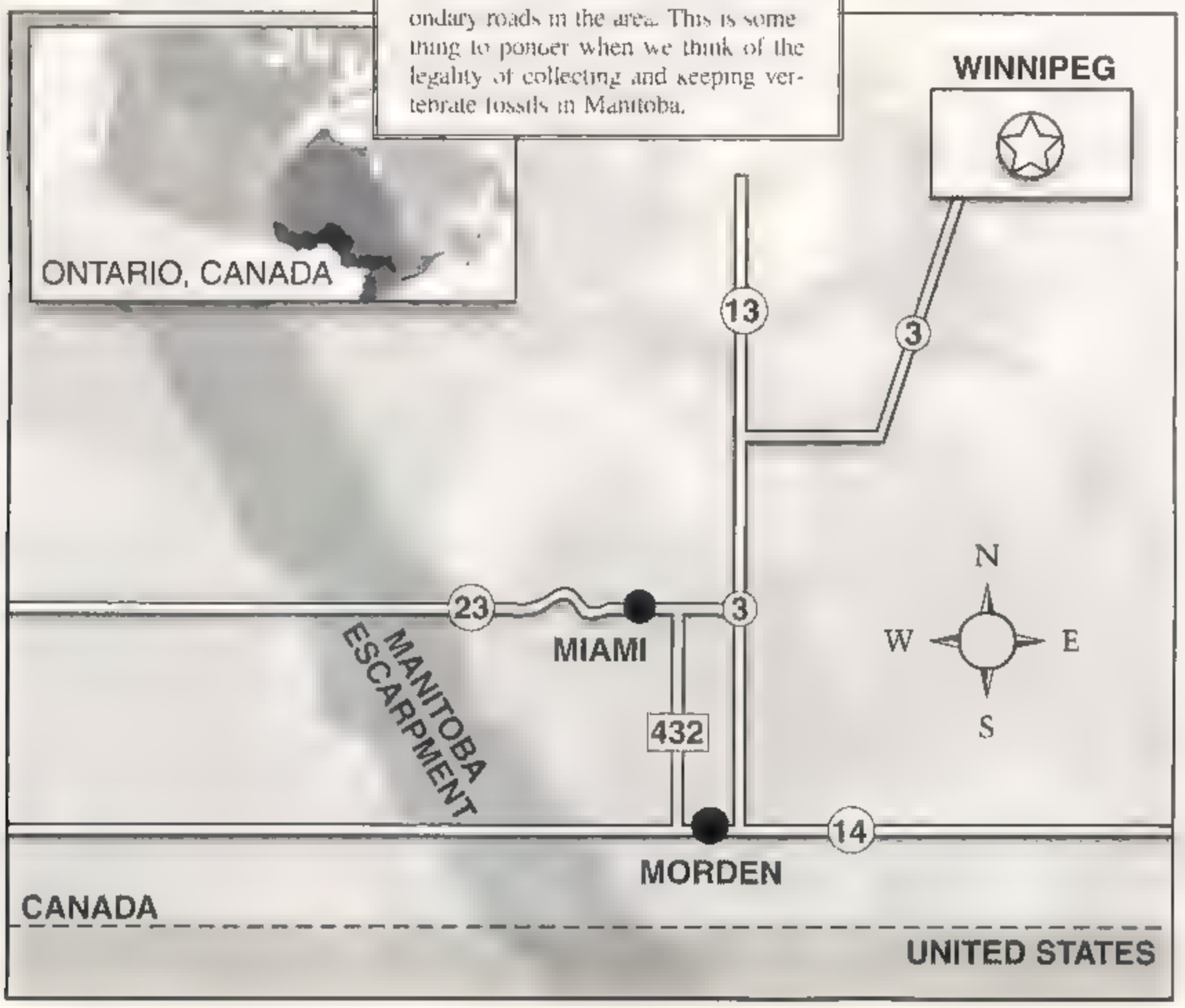
At the Gillis Limestone Quarry near the town of Tyndall, Manitoba, during summer months, families can collect vertebrate fossils every Saturday on the rubble dump for a reasonable fee of $25 Canadian per vehicle. This dump is composed of tons of discarded blocks of fractured and imperfect Tyndall stone. The fractures and imperfections are due to the fossil bones imbedded in them, making them unfit for building blocks. The collecting fee may change, so be prepared. Also, I would advise taking along a hard hat, safety glasses or goggles, hard-toed shoes, and gloves, plus a rock hammer and other favorite tools.

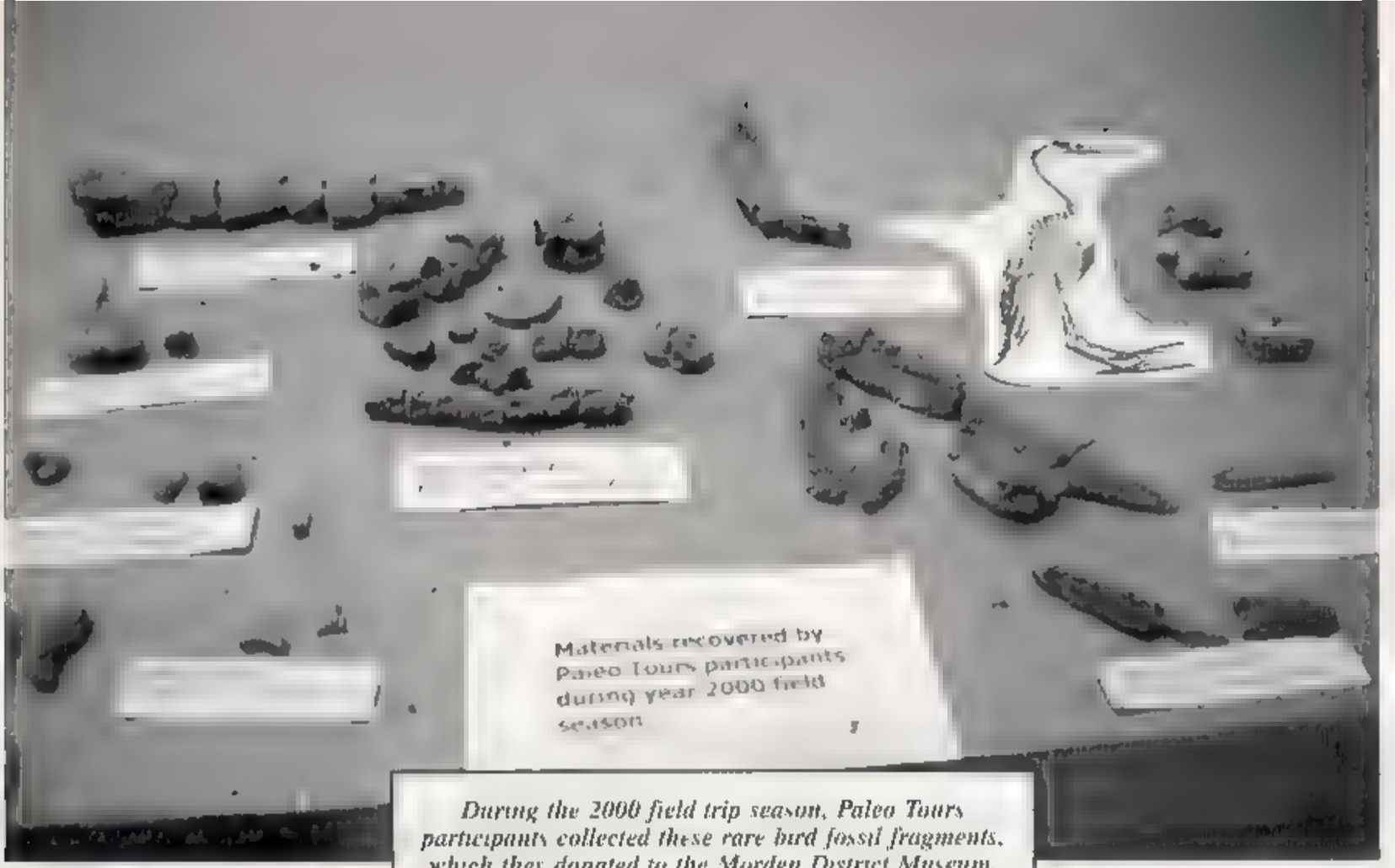
Tyndall is 18 kilometers (11 miles) east of Winnipeg on provincial Highway 44. The discarded rock, with all of those magnificent fossils, is crushed and used for surface material on secondary roads in the area. This is something to ponder when we think of the legality of collecting and keeping vertebrate fossils in Manitoba.

After searching the old pit, I gravitated to an exposed, eroded area east of the mine. Here, one of the museum workers brought a container holding the tools of the trade. Those of us who so chose were invited to take paintbrushes and trowels and work on an area of our own. We were told to start by making a squared-off, flat area as large as we could reach while kneeling, and carefully brush the loose overburden away. Using the trowels, if necessary, to get down to a layer of shale 2 or 3 inches below the surface rubble. What we were after was hidden in the crumbly shale layers.

What a thrill it was to carefully remove a slab of shale with my pocketknife and discover perfect imprints of fish scales. I was the first one to see them in perhaps 80 million years. It's mind boggling simply to try and comprehend such a time span. It also makes one realize our mortality. I would imagine that if we spent more time at the site, we might have been able to uncover some bones of those fish that died so long ago.

Due to the rainy conditions the night before, we were unable to get to another site that holds the remains of many mosasaurs. The road was impassable. But despite this, we had a most educational and interesting day at the Manitoba Escarpment.





During the 2000 field trip season, Paleo Tours participants collected these rare bird fossil fragments, which they donated to the Morden District Museum.

Paleo Tours participants do get to keep most things they find. Of course, if they find a rare bone or group of bones, it is requested that they donate them to the museum.

Upon our return to Morden, we were given a tour of the museum. Here we saw the largest collection of marine reptiles anywhere in Canada. They were beautifully prepared and put on display in well lit cases. It was a most impressive experience, and a fitting end to our day's outing.

If you're in the area and wish to have a most educational and exciting adventure including a very interesting guided tour, at a reasonable fee, contact Mike Waddell at Morden District Museum, 111 B Glenmoar St., Morden, MB R6M 1N9, (204) 822-3406, e-mail: morden.museum@mb.sympatico.ca, Web site: www.mordenmuseum.com. You will even get a chance to dig your own fossils, so don't forget to bring along your "grubbies."

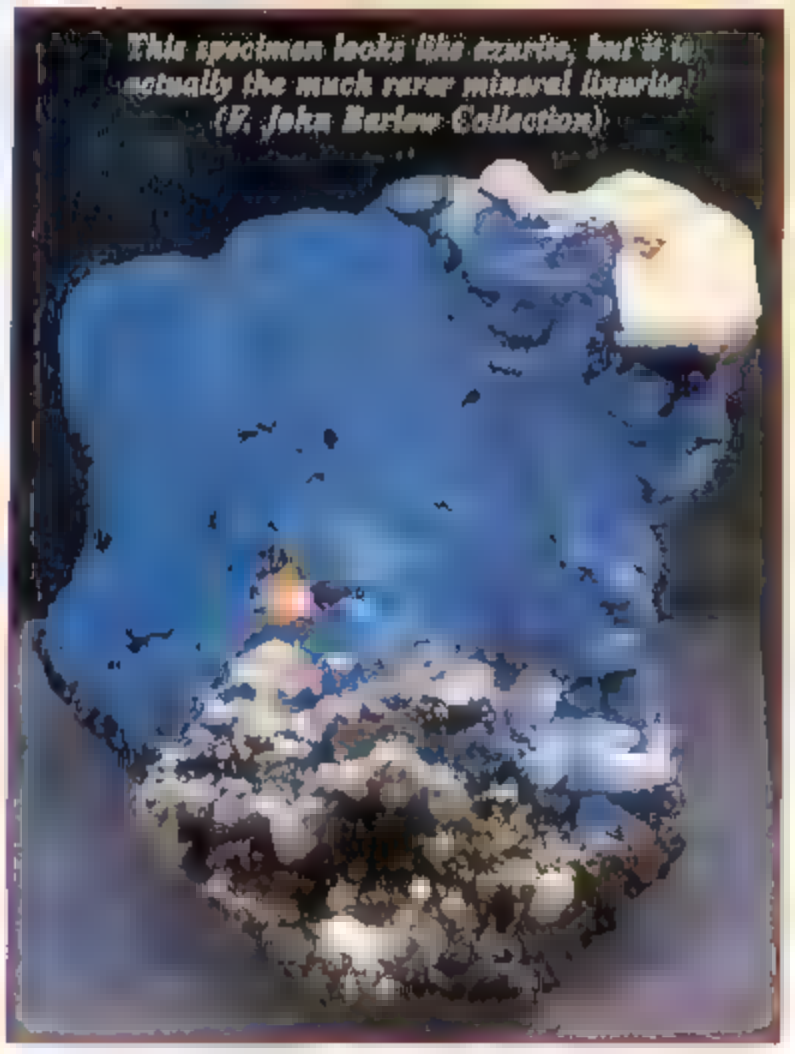
Bear in mind that when traveling to Canada, it's wise to go to a bank and exchange U.S. currency for Canadian. They have the daily rate-of-exchange figures, and you will get the best deal. You will also avoid much confusion by using Canadian money. Also, your vacation dollars go much farther while in Canada, which in itself is a very good deal.

Crossing into Canada is usually only a formality. However, the border guards do inspect vehicles from time to time, as they did mine on this trip. Take along a birth certificate or some other form of identification and proof of vehicle insurance. It's that simple.

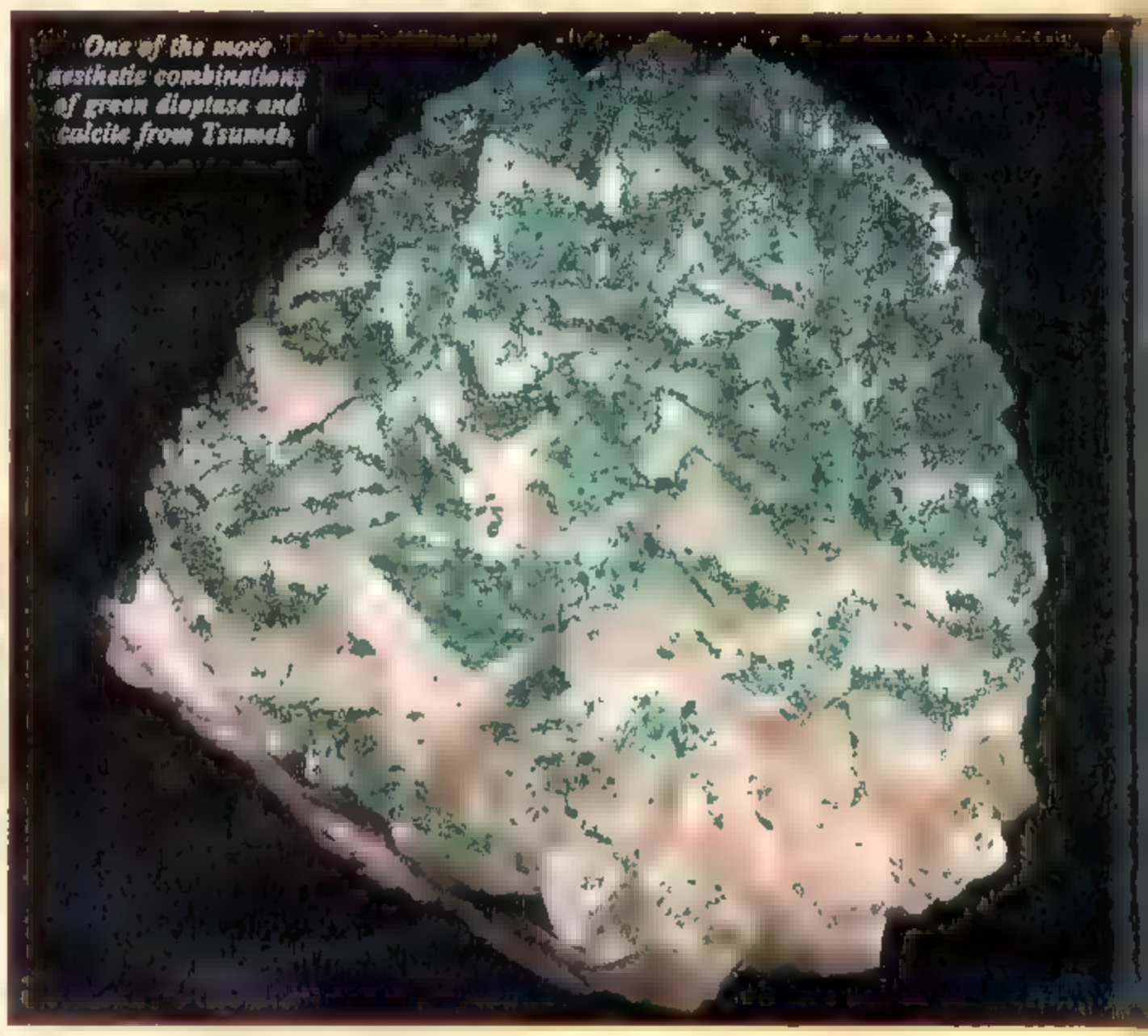
So why not take advantage of this opportunity and visit Manitoba. You can join a tour group in Morden, or strike out on your own. Either way, the potential for a great adventure is there waiting for you.

The Remarkable Minerals of TSUMEB

This crystal of nambulite, one of Tsumeb's rare species, from the F. John Barlow Collection is one of the largest ever found. (Photos by the author)



This specimen looks like azurite, but is actually the much rarer mineral linarite. (F. John Barlow Collection)



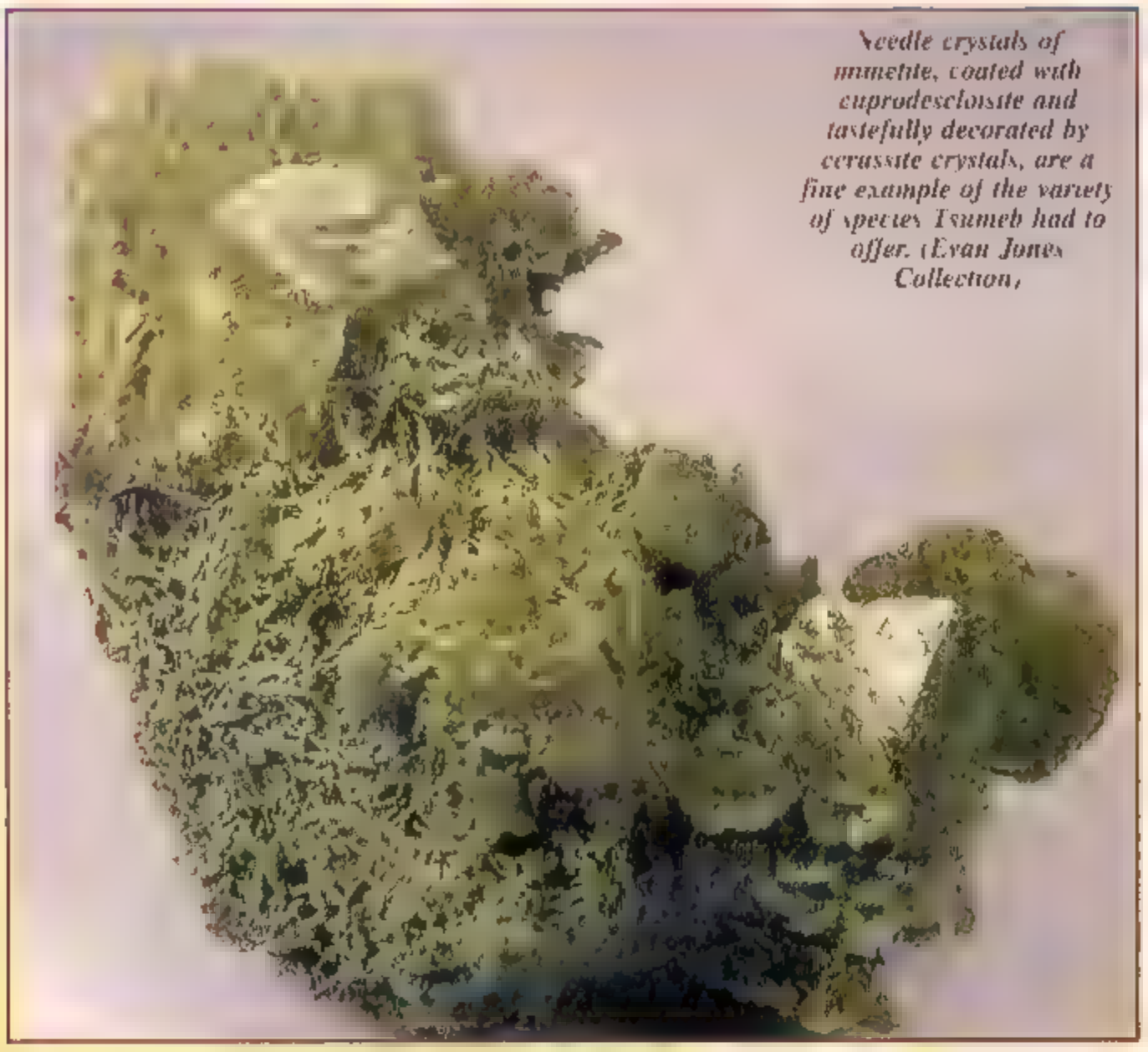
One of the more aesthetic combinations of green dioptase and calcite from Tsumeb.

Quite Possibly the World's Greatest Mineral Deposit

by Bob Jones

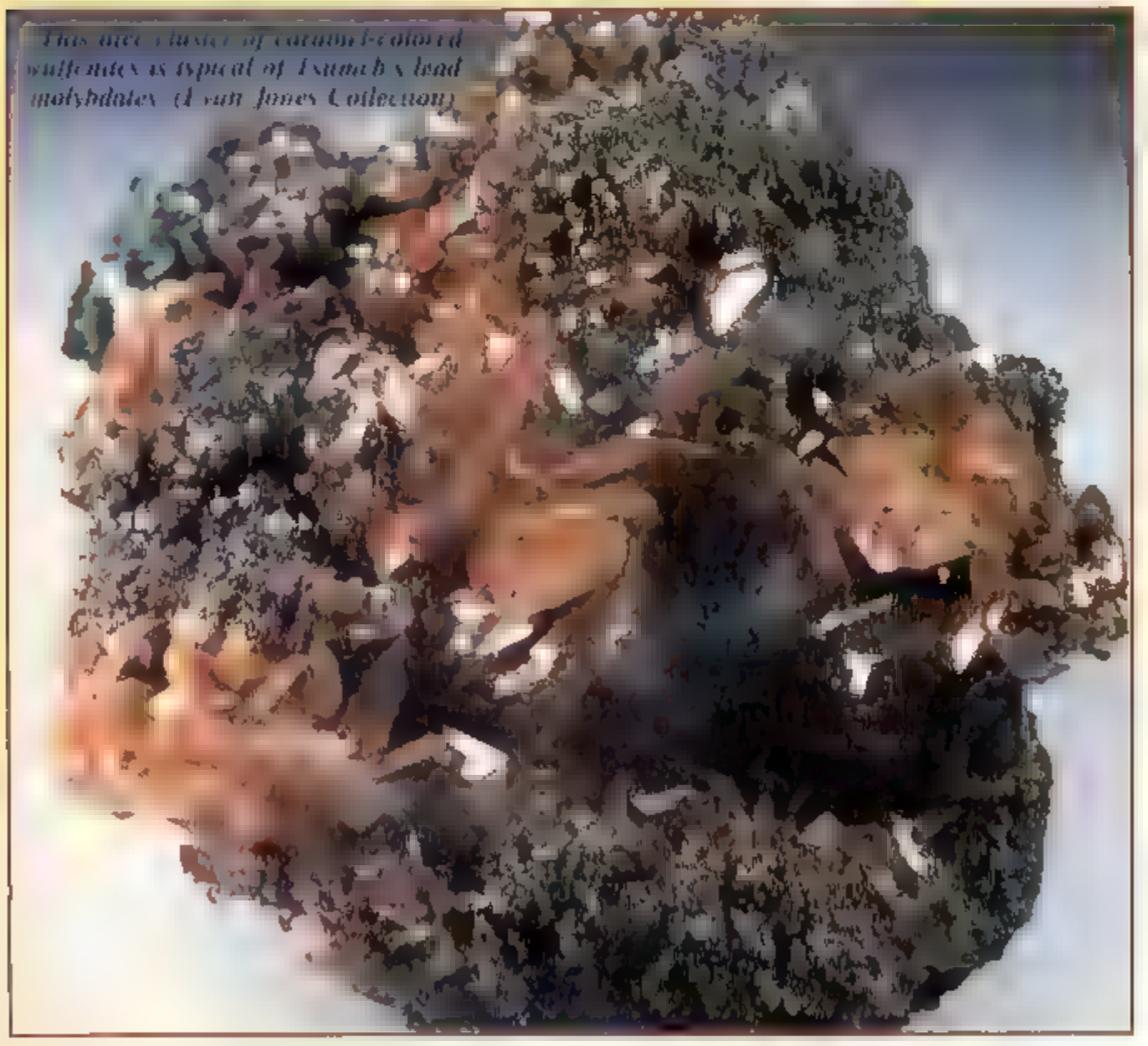
The theme of the 2002 Tucson Gem & Mineral (TGMS) Show is Gems and Minerals of Africa. Mention Africa and every collector immediately thinks of Tsumeb!

Tsumeb! The name causes every mineral collector's eyes to brighten and every mineralogist to smile. And for good reason. It is considered by most to be the greatest specimen-rich ore deposit ever mined, and perhaps the most exciting source of rare and new minerals. The Franklin Sterling Hill ores of New Jersey or the Bisbee, Arizona, ore deposit may have produced more species, but Tsumeb, Namibia is dear to the heart of every member of the



Needle crystals of mimetite, coated with cuprodescloisite and tastefully decorated by cerussite crystals, are a fine example of the variety of species Tsumeb had to offer. (Evan Jones Collection)

This 9-inch group of azurite/malachite is from the "Old German Stope" of the upper oxide zone. (Evan Jones Collection)



This nice cluster of caramel-colored wulfenites is typical of Tsumeb's lead molybdates. (Evan Jones Collection)

collecting and mineral science community because of the vast variety of collector-quality colorful minerals and fascinating rare and new species found there.

Namibia, formerly South West Africa, is a mineral rich country. Diamonds are found along its Atlantic coast. A number of its gem mines are well known, and its ore mines have produced tons of metals.

Tsumeb is located about 300 miles almost due north of Namibia's capital, Windhoek, and about the same distance from the Atlantic. Of real interest to any visitor is the wildlife-rich Etosha Pan, a national park, just north and west of Tsumeb. Any visit to this mining community should be followed by time spent at this wonderful preserve.

Unique is the word that best describes this lead-copper-zinc-germanium deposit in the Otavi Highlands. For over a century, a nearly inexhaustible stream of specimens and species has flowed from this deposit. Many of the specimens are the best of the species, while others are new to the mineral world. Still others await the results of testing to determine exactly what they are.

In his book *TSUMEB: A Unique Mineral Locality*, which I highly recommend, Georg Gebhard offers the most complete description of Tsumeb's mineral contributions that I have ever seen. In brief, he says that 242 known mineral species are found at Tsumeb, including 52 species that were discovered there, 40 of which are unique to the deposit. As for examples of the "world's best" of mineral species, Gebhard reports that Tsumeb produced 105 of them. It has also yielded 65 different pseudomorph types. This is an amazing record for any deposit and is one major reason for Tsumeb's worldwide popularity. A second reason for Tsumeb's great attraction is its wonderfully colorful and abundant specimens, which for sheer visual impact eclipse other localities.

continued on next page

The Remarkable Minerals of Tsumeb *from page 41*

I was fortunate enough to visit Tsumeb in the late 1980s. The only unfortunate part of my visit was that mining had ceased, so available specimens were limited in number and of only average quality. Mining in the deeper levels of the Tsumeb mine ceased early in 1996, and in the upper levels by the middle of that year. Today extraction of some remaining support pillars in the upper oxide zone is ongoing, so specimens are occasionally available, but not like in previous decades.

Just when the ores of Tsumeb were discovered is lost in time. The early businessmen of Africa worked it for an unknown number of centuries to obtain the surface oxides and carbonates for trade with the Ovambo natives. This advanced culture knew how to smelt the ores to obtain copper, which they used for jewelry and trade.

It was not until the mid-1800s that two Europeans arrived in the area and reported the presence of copper. Nothing came of that visit, but in the last quarter of the 1800s copper mining began at Otavi, about 30 miles from Tsumeb. Finally, just before the turn of the century, Europeans arrived at Tsumeb to determine the viability of mining there. They immediately began surface mining of copper ores. The deposit proved to be extremely rich, and this stirred interest in development of the ores by German interests. Production was severely limited because of the great distances ore had to be transported. Water was plentiful, thanks to the karst landscape where lakes could form. A karst landscape is full of potholes and depressions where the limestone formations have been partially dissolved by erosion and where subsequent collapsing has created shallow depressions.

Tsumeb's ores were deposited by hydrothermal action in Precambrian times. The host rock is largely dolomite, with some sandstone formations as well. Metal-bearing hydrothermal solutions attacked the dolomite, opening cavities and widening faults and cracks where mineral deposition could occur as the solutions gradually cooled and dropped their loads.

Normally in a fairly dry or desertlike environment, weathering develops to considerable depths, more than 1,000 feet into the earth, is not unusual. Though Tsumeb experiences a little more rainfall than the Namib or Kalahari deserts of Africa, the region still has its long, dry season. Toward the end of the dry season is the best time to visit the region, as the wild game tends to migrate closer to the remaining waterholes.

Just north of Tsumeb is the famous Etosha Pan, a wonderful, vast salt pan that is host to a variety of wildlife, which lives off the sparse vegetation, and where water holes persist. On a visit to the salt pan I enjoyed watching elephants, rhinos, giraffes, zebras, hyenas, ostriches, lions, and other assorted wildlife in and around the waterholes of the Etosha.

Be that as it may, Tsumeb had an upper oxide zone that extended at least 1,000 feet down, and it yielded the first vast amounts of superb specimens of cerussite, azurite, and many other minerals. These specimens immediately caught the attention of collectors and scientists. Choice azurite, malachite, dioptase, smithsonite, cerussite, all the familiar oxides, ores of a lead-copper-zinc oxide deposit, were mined and collected. Most of these ended up going to Europe because of the deposit's German developers.

Below the oxide zone, miners encountered a massive sulfide zone, typical of such a hydrothermal deposit. But what made Tsumeb unique, and also resulted in an even greater number of superb and rare species and specimens, was the fact that Tsumeb boasted not just that one large oxide zone where weathering had created such a superb suite of species. As mining proceeded at depth, a second and then a third oxide zone was encountered. The presence of three oxide zones in one ore deposit was unheard of. No wonder Tsumeb produced wondrous minerals in quantity again and again.

How could this be? How could the necessary chemical ingredients, oxygen and carbon dioxide laden waters, get below the sulfide zone, which is normally an effective barrier to surface waters? Only above and at the upper boundary of the sulfide zone would oxide minerals normally be encountered. What could have caused such an unusual situation in which more than one oxide (weathered mineral zone could develop? How could the deep sulfide ores of a deposit be attacked from below, resulting in those very surfaces developing carbonate, arsenate, phosphate, vanadate and oxide species?

The answer is the North Break Fracture. This wonderful (from a collector's viewpoint) earth fault cuts at an angle from the surface down across the Tsumeb hydrothermal ore deposit. It has allowed surface waters, over millions of years, to travel downward, bringing oxygen, carbon dioxide rich waters in contact with the deep sulfide ores, resulting in a new oxide zone each time it happened. Since the ore body was a curving, rather vertical, "S" deposit, the North Break Fracture actually crossed the ore body twice at depth, and each time caused oxidation to occur. So, along with the surface oxide zone, these two deeper oxide zones, at about 2,600 feet and 3,500 feet, caused a resurgence of specimen production of Tsumeb's spectacular oxide mineral horde.

Of the more than 240 species that occurred at Tsumeb, a considerable number were the species common to oxidized lead-copper-zinc ores. These include azurite, malachite, dioptase, cuprite, native copper, cerussite, wulfenite, anglesite, mimetite, smithsonite and willemite, as well as gangue minerals like calcite in marvelous varieties and dolomite.

As Tsumeb became better known and more accessible after World War II, greater numbers of specimens came on the market. It was not uncommon in the 1960s, '70s and '80s for a huge lot of one species to suddenly show up on the market. I can recall one year in Tucson when well over 100 flats of superbly crystallized green dioptase were available at reasonable prices. Another year it would be cerussite, snow-white, twinned and beautiful. Still another year it was lusciously pink smithsonite. I recall one dealer who frequented Tsumeb telling me of a pink smithsonite occurrence in the mine which was revealed by a blast that peeled open a wall completely covered by the rounded, cobalt-tinged zinc carbonate species. Unfortunately, little of this particular occurrence was saved, as mining proceeded unabated. Still, for a time there seemed to be plenty of pink and other colors of smithsonite on the market.

The upper oxide zone certainly produced its share of superb specimens. One of the German mine managers, Friedrich Kegel, brought a wonderful collection back to Switzerland when he retired before World War II. His collection was later bought from his widow by the Smithsonian Institution, where much of it remains today. A few Kegel specimens ended up in the Mark Chance Bandy collection, now at the Los Angeles County Museum of Natural History. Mark had the delightful task of traveling to Switzerland to pack and ship the Kegel collection to the United States when it was bought. His pay was a small selection of choice Tsumeb duplicate pieces which I enjoyed viewing many times before they went to Los Angeles.

The original outcrops at what was to become Tsumeb were two large, domed "greenish" weathered outcrops of the deposit. Cobbing gives the size of the combined outcrops as some 180 meters by 40 meters and about 22 meters high. On my visit the remains of those outcrops minus their riches were still visible.

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The Remarkable Minerals of Tsumeb *from page 42*

The first European mining was done by open pit, though small shafts were put in early on. The outcrops were separated by a sandstone formation. One end of the ore outcrop was later shown to contain mainly copper ores, while the other end was more of a lead deposit. Fortunately, each produced an overwhelming number of species and specimens during mining operations.

In discussing such a deposit, with such a variety of superb species, space simply does not allow that every species be described. I leave it to you to research, with the recommendation that you purchase a copy of Giebhard's book as soon as possible. You'll marvel at the in depth treatment of the deposit and the really breathtaking series of nearly 300 photos in color and black and white. It is a "must-have reference for your bookshelf.

My choice of minerals from Tsumeb is influenced by where I live in the Southwest. Copper, lead and zinc species are a way of life for southwest collectors, so azurite, malachite, smithsonite, mimetite, cerussite, anglesite, leadhillite and dioptase are among my favorite Tsumeb minerals. I would be the first to admit that micro crystals and smears on rock hold little interest for me as a collector. They interest me from a scientific angle, but find little space in my collection. So for me, the rarities from Tsumeb are fascinating, but not my choice.

I can think of three azurites that rank as the best I've ever seen. The Smithsonian specimen of a group of several lathelike dark blue crystals that are a stunning 10 inches long is spectacular. Then there is the American Museum of Natural History's "bird's nest" azurite, a shallow nestlike cluster of brilliant, doubly terminated, 5-inch, nearly black azurite crystals. I find that specimen particularly stunning. The piece was formerly owned by Newmont Corp., which operated the Tsumeb properties for a time.

The third azurite that stirred my interest is a 6-inch blade with a bright green rosette of radiating malachite smack in the middle of its prism face. I first saw it in the famous German collection owned by Carl Bosch when the collection was housed at Yale University in the 1950s. The Bosch family eventually sold its collection to the Smithsonian.

The American Museum/Newmont bird's nest azurite, like most noteworthy specimens, has gathered a couple of tales about it. It seems the specimen was originally traded for drinks at the Minen Hotel bar years ago. A Newmont official got wind of it and demanded the return of the wandering piece. It ended up in Newmont's New York office on display in the lobby.

The American Museum will be bringing the bird's nest azurite to the TGMS Show in February. This will be the prized specimen's second visit to Tucson. Some years ago it was loaned to the Society for display. When a company official went to get the specimen from its lobby display case, he discovered that the case was unlocked and had been for years! There was also a huge crystallized gold specimen in the same case. Who says collectors aren't honest?

Tsumeb's malachites, though found in fair numbers, never exceeded in quality what I was used to seeing from Arizona's copper mines, so I can't recall any particular one that caught my fancy. Still, some of the malachite pseudomorphs after azurite are classy to say the least. Many reach lengths of 5 or 6 inches. Others form in stacks, while still more occur in diverging sprays of thin blades that were once azurite.

TSUMEB:
A Unique Mineral Locality

by Georg Gebhard
G G. Publishing
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Grossenseifen, Germany
USD $.25
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The text will also be available from dealers at the Tucson Gem & Mineral Show.

Of the cerussites that have come from Tsumeb, my favorites are what are commonly called "snowflakes." These are snow white, reticulated, twinned cerussites, sometimes up to 6 inches across, that exhibit a more or less hexagonal shape, which results from repeated reticulated twinning. Sometimes these beauties are nearly glass-clear, sometimes a bit smoky, always breathtakingly beautiful. Who says white minerals are not exciting to look at?

The thing that I marvel at about cerussite is the number of specimens that have come to ground from Tsumeb. Surely, tens of thousands of these lovely lead carbonate beauties have been mined. Most are V twins, but many are reticulating twins, while others are long, striated singles. Some have been tinted red by iron oxides, others have a dusting of a green copper mineral. Still others are simply snow white and many inches long.

My favorite dioptases are those with bright green crystals scattered on a white crystallized calcite matrix. More abundant are the rich green plates of interlocking trigonal crystals that sparkle brilliantly. Doubly terminated inch long crystals are common. Many show a green zoning effect, ranging from light to dark green in a single crystal. Yet, the high contrast between the delicate green dioptase and the snow-white calcite makes for very showy specimens.

Another species that has been found at Tsumeb in quantity is mimetite. It occurs there in several habits, which I like. The sharp needles of this bright-yellow lead chlorarsenate are very attractive. Just as pretty, and completely different, are the hexagonal, blunt, barrel shaped mimetites that can range from yellow to orange in color.

Of course, wulfenite, a lead molybdate, has to rank among Tsumeb's fine display species. The number of wulfenite specimens is not huge when compared to cerussite for example. Yet enough specimens can be seen to make Tsumeb wulfenite a worthy addition to many collections. It occurs in several lovely colors, mainly some shade of yellow to tan. The best crystals are bright-yellow tabular crystals, usually thick in the middle, measuring up to an inch or so on edge. Others are a deeper tan to honey color, sometimes in thick tabular crystals that reach 2 inches on an edge. Some border on orange, but don't quite compare with Arizona's best.

I've already mentioned pink smithsonite as an exciting Tsumeb specimen. This zinc carbonate actually comes in a host of colors. It can range from nearly colorless to pink to green to blue, depending on what metallic impurity has invaded its structure. Crystals can be the classic trigonal rhombs or form in nearly rounded crystal intergrowths to an inch or more across. Some crystals may reach 2 inches on an edge, but smithsonite tends to occur in fine crystallized groups of individuals that are under an inch each.

As I mentioned, the 2002 Tucson Show is to take place Feb. 14–17. Its theme, Gems and Minerals of Africa, will certainly bring out a stunning array of superb mineral displays from all over Africa, with Tsumeb leading the way. Every museum—and more than 20 will be invited—can put in prize-winning African and Tsumeb displays. And private collectors who specialize in Tsumeb minerals will easily compete with the museums for the attention of the visitors. Together they will provide the largest and most spectacular exhibition of African and Tsumeb minerals ever seen under one roof.

I urge you, while visiting the show, to buy a copy of Gebhard's book, *TSUMEB: A Unique Mineral Locality*. This text is the definitive work available on Tsumeb, and will make your visit to the TGMS Show a learning experience while you enjoy the best of Africa's minerals.

PROJECT:

Make an INLAY Objet d'Art

Create This Decorative Piece to Display in Your Home

by Max A. Hatch

Most lapidary projects are made to fulfill a specific function, usually as a piece of jewelry. After all, when you have invested many hours and possibly a considerable amount of money in the fabrication of a piece, you want to show it off. There comes a time, however, when you have more belt buckles, bola ties, pendants, pins and bracelets than you and/or your spouse can possibly use. This is the time to make something that is meant to be on display in your home, not on your person. This is the rationale behind this project. To make a lapidary project for display purposes only.

A significant branch of my family tree had roots in the ranching business, raising Hereford cattle. I decided my project would reflect this heritage, a Hereford bull of stone inlay in silver. The same method is used for many bola ties and belt buckles. This bull would be attached to a base and placed on a display shelf as a stand-alone figure.

Method of Construction

Find a picture of a Hereford bull (any picture could be used) that shows an acceptable profile and use tracing paper to make an outline of the subject. With a photocopier, enlarge the drawing to the desired size. Using color markings and anatomical features, draw sections on the picture that will be outlined with the bezel wire. Once you are satisfied with the drawing, make several photocopies of it.

Prepare your pins. Use a pair of side cutters to cut the heads from ordinary straight pins. Use a small pair of pliers to bend the top of the pin into an inverted U shape.

Cut one of the copies of the bull outline from the larger sheet of paper, and use a couple of pins to fasten it to a smooth side of the fire brick.

List of Materials:

- 24 gauge silver sheet, approximately 2 inches x 3 inches
- 1/8 inch x 24 gauge silver bezel wire
- Small diameter silver tube
- Silver wire
- Rock slabs of your choice, at least 1/4 inch thick
- Slab of ironwood, approximately 1/2 inch thick, 3 inches wide and 8 inches long
- Assorted plant parts to simulate brush and trees
- Silver soldering supplies and torch
- Paper, pens, pencils and stylos
- Picture of a Hereford bull
- Fire brick, with at least one smooth face
- Packet of pins
- Ordinary hand tools such as pliers, snips, etc
- Dremel or other motor tool with a drill press type stand
- Assorted grinding tools for the motor tool
- 6 inch or 8-inch grinding and polishing unit

Beginning with the outline, form the bezel wire to the shape of the bull and fasten it over the outline with the bent pins. Keep the bezel vertical to the outline. File the ends of the bezel pieces to make smooth connections at the joints. Be careful with your pin placements in regards to small joints. Remember, you will be soldering these joints, and you do not want to solder the pins to the bezel wire. When the framework is complete, it is time to solder all the joints.

By far, the best method to use in soldering all these joints is the "probe" method. Using sheet or flattened wire hard silver solder, cut many small pieces and scatter them over an area of your soldering block. Flux all the joints to be soldered. Hold the point of your solder poker over a solder snippet and play the flame from your torch over the snippet, which will roll into a ball. Touch the tip of your poker to the red ball and it will adhere to the ball. Move the poker and solder ball to a joint and heat the joint with your torch. As it reaches soldering temperature, touch the solder ball to the joint, and it will flow into the joint.

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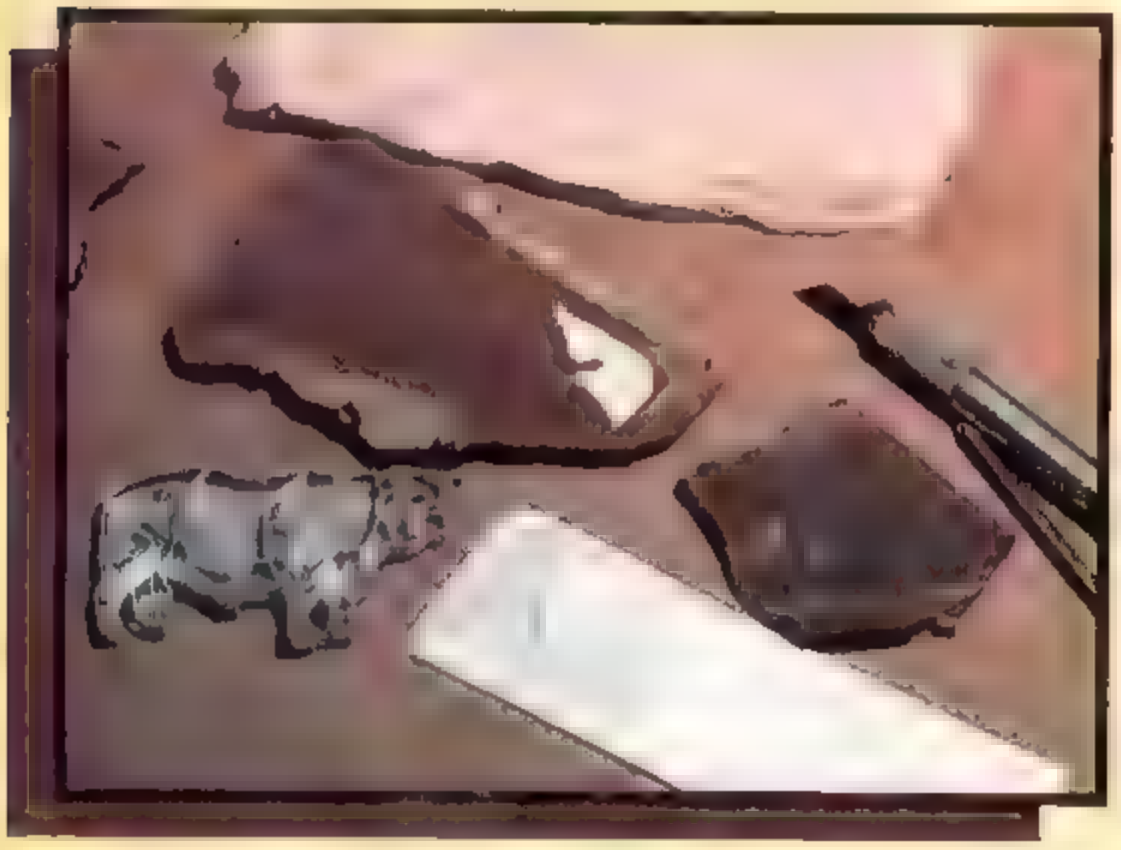
Pin the 24 gauge bezel wire to the outline of the subject. Make all jounts tight. (Photos by the author)

Solder all the jounts and sand the frame on a smooth surface

Solder the frame to the backing plate and saw away any excess.

Use a mallet and a large, rounded, wood drawer pull to give the frame a slightly convex shape.



Use an aluminum pencil to make a rubbing of the outline on a piece of paper.

Cut each section from the rubbing and epoxy to the corresponding slab. Grind the slabs to shape.

Make an Inlay Objet d'Art *from page 49*

Epoxy a piece of silver tubing to the back of the piece. Center a length of silver wire in the tube, bend at 90 degrees, and insert the ends in the holes drilled into your base.

I actually performed two separate soldering sessions on my first pair. I did not think I could make successful joints at some of the places where there were a number of small, short pieces in close proximity, such as on the face. I soldered the longer pieces in place, then placed this frame over a new outline sheet, pinned the remainder of the pieces in place, and soldered them. As you do more of this type of soldering, you will gain confidence and skill, and this two-step process probably won't be necessary.

When all the solder joints have been made, take the framework from the fire brick and inspect it. Make certain that every joint is a solid solder joint. If there are any weak joints, re-solder them. If there is any solder buildup, use a small file to remove it. It is not necessary to pickle the frame at this time.

Place a sheet of fine grit sandpaper on a flat surface, such as a piece of heavy glass. Hold the framework flat on the sandpaper, and using a figure 8 motion, clean and flatten the bottom side of your ball. This is the side that will be soldered to the flat silver sheet. Be certain that all pieces of the framework are clean and flat, and will make good contact with the backing piece.

Place your backing plate on a soldering stand. Squirt some self-pickling flux onto the plate and set the ball framework on it. Roll the frame around in the flux to be certain all meeting surfaces are well covered. Using hard silver solder, solder the frame to the backing plate.

Next, pickle the piece and check for gaps in the solder. Repair any that are found. Use a jeweler's saw to cut the excess backing plate from the bezel, and a fine file to create a smooth finish. You may use Tripoli on various wheels to clean the back and sides of the silver piece. It is not necessary, nor even desirable, to polish the silver at this time.

Put the piece face-down on a heavy, folded towel and use a large wooden drawer pull or other rounded form to give the piece a slightly convex shape.

Place a sheet of paper over a section of the ball and rub an aluminum maker over the edges of the bezel. This will give you an exact outline of each section. Use a small blade in an X-acto knife to cut the outline pieces free. Epoxy each piece to the appropriate stone slab. I used three slabs for my ball: a piece of reddish jasper, a slab of ball quartz, and a small slab of pinkish feldspar.

Each stone piece must be formed to fit its intended place in the design. Use a trim saw to remove each piece from its slab and trim as close as possible to the outline. Use a combination of large, small and specialty grinding wheels and bits to finish each piece. Try for an exact fit.

Mix clear epoxy, or better yet, tint it with colors such as those sold by Tapp Plastics to the same shade as your stones. Epoxy each piece in place and let cure overnight.

Use regular grinding and polishing procedures to grind the stones flush with the silver bezel and polish them. This step is the reason for the slightly convex shape. When the stones are polished, use black rouge or your favorite polish to finish the silver work. It may be necessary to use a shoelace or string to get into all the nooks and crannies of the shape.

Since this piece is meant for display, you must now make a display stand for it. I selected a slab of ironwood that had an interesting texture to serve as a base.

Cut a short length of silver tube. Insert a piece of silver wire through the tube and cut to approximate length. Center the wire in the tubing and bend each protruding leg to a 90-degree angle. Epoxy the tubing to the back of the ball, being careful not to let epoxy enter the ends of the tube. Let the epoxy cure until solid.

Form the wire so that the ends are hidden behind the legs of the ball. Drill two holes in the ironwood where you wish the ball to stand, and epoxy the wire in the holes. The ball is now standing on a basic piece of wood.

To give the piece some more realism, use bits of plastic or silk greenery to simulate plants, trees or whatever you can imagine. The stems can be epoxied into small holes drilled into the wood. Use very small stones, such as those found in decomposed granite, to further enhance your "land scape." Stones or greenery can be used to hide the wire legs of the stand and to hide or enhance leg and foot positions.

You now have a decorative piece that you can put on display with your other objets d'art. It will not only impress your friends with your craftsmanship, but also with your cleverness for creating something out of the ordinary.

The Future of Leadville, Colorado

Looking east toward the Mosquito Range, a photographer captures the headframe and hoist shack of an old mine in the Leadville Mining District. (Photos by the author)

A Metal-Mining District Turns to Tourism

by Steve Voynick

Jan. 26, 1999 was a landmark day in the history of Leadville, Colorado. On that day, ASARCO's Black Cloud Mine—a lead, zinc, silver and gold producer for the past 29 years, shut down. Although the Black Cloud was neither much larger nor much different than hundreds of other Leadville mines that yielded the same metals, its closing rated national attention, with articles appearing in weekly newsmagazines and in 246 newspapers. The shutdown was newsworthy because it left Leadville without an operating mine for the first time in 140 years, ending a longevity record unequaled by any other American metal mining district.

Leadville's name had always been synonymous with metal mining. In a rollicking history that began with the 1859 Pikes Peak gold rush, the Leadville Mining District and the nearby Climax Mine continued to produce a fortune in metals world (conservatively calculated by year-mined values) staggering $6 billion.

But today Leadville is a mining town without operating mines. It stands at a crossroads in its history and struggles with economic transition. Yet, even though the thundering rock drills are finally silent, Leadville remains a place of mines and minerals. It is a National Historic Landmark District with a rich mining history and heritage, fine museums, and a sprawling, old mining district where collectors still find mineral and ore specimens. Set amid some of Colorado's most spectacular mountain scenery, Leadville, at an elevation of 10,152 feet, is North America's highest incorporated city. For anyone interested in mining, mining history and minerals, Leadville—even without any operating mines—is well worth a visit.

Leadville is 106 miles and two lofty crossings of the Continental Divide west of Denver. At an elevation of 10,150 feet, it's the highest city in North America. It's located in the shadow of the Mosquito Range, a rugged ridge of 14,000-foot peaks to which it owes not only its elevation, but much of its scenic beauty and all of its mining fame and fortune.

The Mosquito Range was created some 65 million years ago during the Laramide Orogeny, the mountain-building episode that uplifted the Rocky Mountains. Crustal stresses, generated by the collision of distant edges of tectonic plates, thrust upward great blocks of granite basement rock through overlying formations of Devonian and Mississippian limestone. The resulting faults and fractures became conduits for the upward movement of porphyry magmas and associated, metal-rich hydrothermal solutions.

In what would later become the Leadville Mining District, these solutions emplaced rich, multimetal mineralization as both vein deposits in altered granite and massive, limestone-dolomite replacement deposits. The original mineralization con-

Specimens of pyrite, galena and sphalerite were collected from mine dumps in the old Leadville Mining District

sisted of galena, sphalerite and pyrite, the respective sulfides of lead, zinc and iron, along with lesser, but significant, values of silver, gold and copper.

Much later, Pleistocene glaciers scoured the Mosquito Range, exposing the uppermost parts of these deposits to atmospheric oxygen. Oxidation altered the exposed sulfides to cerussite (lead carbonate), smithsonite (zinc carbonate), and chlorargentite (silver chloride), while also enriching the metal concentrations. Nearby streams concentrated the heaviest minerals—native gold and the black sands of argentiferous lead carbonate—in small, but extraordinarily rich, placer deposits.

Leadville's story began in 1859 when prospectors found placer gold in California Gulch, a narrow draw so named because the discovery pans seemed to hold "all the gold of California." In just five years, California Gulch, the richest placer strike of the Pikes Peak gold rush, yielded 250,000 troy ounces of gold worth nearly $5 million. By 1860, a population of 10,000 had made the ramshackle boom town of Oro City, the forerunner of Leadville, the largest settlement in Colorado Territory.

The placer gold quickly played out, leaving Oro City all but deserted by 1865. The few miners who remained to coax a bit more gold from the well-worked gravels of California Gulch spent much of their time cursing the seemingly worthless, heavy, black sands that continually clogged their sluices.

Hard-rock gold fueled a brief economic recovery in Oro City in 1868. Several small underground "quartz" mines yielded beautiful specimens of crystalline and wire gold, which promoters displayed at eastern and European expositions in a futile effort to attract development capital. But the hard rock gold veins, while rich, also proved elusive and erratic, and the mines soon closed.

In 1874 chemists finally identified that troublesome, heavy, sluice-clogging sand in California Gulch as argentiferous cerussite—lead carbonate carrying small amounts of silver. Prospectors soon traced the lode source of the cerussite to a series of shallow deposits in the nearby hills. Lead, then worth less than a penny per pound, offered little chance for miners to get rich. Nevertheless, when a new camp sprang up around a small lead smelter at the nearby mouth of California Gulch, miners named it Leadville, after the metal that seemed to promise at least a token measure of economic prosperity.

That promise came true, but on a scale that exceeded even the wildest expectations. In 1877, miners searching for more cerussite sank shallow shafts into huge pockets of ore. When assays revealed that the lead carbonate contained as much as 1,000 troy ounces of silver per ton, bust turned into boom almost overnight.

Leadville quickly picked up two nicknames, "Carbonate Camp" for its fantastically rich silver-lead ores and "Cloud City" for its lofty elevation. By 1880, despite the long winters and thin alpine air that made both living and mining difficult, a population of 30,000 had turned Leadville into the largest city between St. Louis and San Francisco. That year alone, 400 small underground mines yielded 10 million troy ounces of silver and 33,000 tons of lead, all of it direct smelted from just 144,000 tons of exceedingly rich ore.

Leadville soared from rags to riches, and so, too, did many mine owners, but none as quickly as storekeeper Horace Austin Warner Tabor. In 1878, Tabor grubstaked two miners with equipment worth $64 in return for a one-third interest in anything they found. What they found happened to be a fantastically rich silver-lead deposit that became the Little Pittsburg Mine. Tabor and his wife, Augusta, quickly bought out their partners and became Leadville's first millionaires.

To introduce an element of culture to this rough and rowdy city, the flamboyant Tabor built an opera house and a grand hotel, both of which still stand today. But to Augusta's dismay, her husband's lavish spending attracted the attention of beautiful, younger women, among them Elizabeth Bonduel McCourt Doe, a divorcee known as "Baby Doe" for her striking beauty. A highly publicized scandal rocked the town's sedate Victorian sensibilities when a bitter Augusta divorced Horace, who then married Baby Doe. The story of the "Tabor triangle" has been retold many times in books, magazines and the 1956 opera "The Ballad of Baby Doe."

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Leadville's silver boom lasted 15 years before turning to bust in 1893, when Congress repealed the Sherman Silver Purchase Act, knocking federal price supports out from under the silver market. Plummeting silver prices closed Leadville's mines by the hundreds, devastated the local economy, and wiped out Horace Tabor's fortune.

In just 34 years, Leadville had endured a gold boom and subsequent bust and a major silver boom followed by another dismal bust. Remarkably diverse mineralization, however, prevented Leadville from becoming a ghost town. National industrialization was boosting demand and prices for zinc and lead, two metals which Leadville had in enormous quantities. As World War I drove base-metal prices to record levels, Leadville boomed again. In 1916, its mines yielded $6 million to $10 million from zinc alone.

After surviving a post-World War I bust, Leadville boomed during World War II, busted in the late 1940s, then boomed once again during the Korean War. But that was the last hurrah for the Leadville Mining District. By 1958, declining ore grades and increasing operating costs had closed all the district's mines, mills and smelters.

But by then, Leadville had hitched its wagon to molybdenum, an alloying metal used to toughen steel. Twelve miles north of Leadville, atop 11,318-foot-high Fremont Pass, the Climax Mine had been working a huge, low-grade deposit of molybdenite (molybdenum disulfide) since 1917. In the 1930s, Climax engineers introduced a massive, block-cave mining system, driving workings that allowed a huge overhead ore body to crush itself under its own weight, then fall through vertical workings into a haulage level for removal to the mill. With gravity performing most of the work, block-cave mining produced huge volumes of ore at very low cost.

In the 1950s, Climax grew into the world's largest underground mine. It reached its peak in 1980 with 350 miles of underground workings, a huge open pit, and a production of 50,000 tons of ore per day. With 3,200 high-paying Climax jobs, Leadville boomed as never before.

Then in 1982, the boom came to a sudden halt when oversupply and falling demand ruined the molybdenum market. The Climax Mine suspended production, triggering another deep economic bust. Businesses and schools closed, and the exodus of miners cut Leadville's population in half.

The Climax closure left Leadville with a single operating mine—ASARCO's Black Cloud, which since 1970 had mined and milled ores grading 8 percent zinc and 4 percent lead, along with 2 troy ounces of silver and .06 troy ounces of gold per ton. Despite employing only 140 miners, the Black Cloud was single-handedly sustaining Leadville's long mining tradition.

After their mining districts died, most of the West's mining towns either became ghost towns or survived by forsaking their mining pasts and embracing other economic alternatives. In Colorado, well-known former mining towns like Telluride, Aspen, Cripple Creek, Central City, and Blackhawk all allowed either mountain recreation or legalized gambling to virtually wipe out their mining history, heritage and culture. But Leadville is taking a different route. While acknowledging its need to diversify economically, it has no intention of abandoning its rich mining history and heritage.

Leadville's initial effort to promote mining-related tourism was short-circuited when the bill came due for the environmental excesses of its early mining booms. In 1983, the U.S. Environmental Protection Agency (EPA) named Leadville to its "Superfund" priority cleanup list, targeting mine drainage pollution in California Gulch that was adversely impacting the nearby Arkansas River. Mine-drainage water contains excessive levels of acidity and heavy metals, created by the oxidation of sulfide minerals. Pyrite (iron disulfide), which is abundant in most metal-mining districts, is the biggest mineralogical culprit. When exposed to the atmosphere and water either naturally or through mining, pyrite reacts with oxygen to form sulfuric acid and free iron ions.

As the acidic iron-rich mine drainage flows into streams, its acidity decreases, precipitating the iron out of solution as iron hydroxide, which clogs streambeds and discolors rocks a rusty orange. Mine drainage also carries excessive loads of other heavy metals, including zinc, lead,

Visitors explore the abandoned claims of the old Leadville Mining District, which covers 20 square miles in the foothills just east of Leadville.

The 1879 Tabor Grand Hotel, with the annual Boom Days parade passing in front, is the most imposing building on Leadville's historic Harrison Avenue.

silver, copper and cadmium, which in sufficient concentrations can be toxic to aquatic life. Today, after an expenditure of $40 million and 17 years of adverse publicity, water purification plants and other remedial measures have eliminated 90 percent of Leadville's mine-drainage pollution.

In the past, when mining was booming, Leadville always welcomed visitors, although it never needed them. Only in the late 1980s and '90s did Leadville finally make tourism promotion and development a priority.

When the Climax Mine closed, its railroad link with Leadville was abandoned. Seeing an opportunity to convert the old railroad into an excursion line, two Leadville residents purchased the 13 miles of track, a roundhouse, assorted railcars, and two big diesel-electric locomotives. Despite the bargain-basement write-off price of $1.0 for the entire package, large operational, restoration and maintenance costs made the venture a big financial gamble.

But that gamble paid off. Today, the Leadville, Colorado & Southern Railroad is the community's highest standard gauge rail excursion line. Thousands of summer passengers enjoy the clickety-clack of the rails and the wail of the locomotive whistle as excursion trains negotiate tight mountain curves, skirt the edges of sheer cliffs, and pass wildflower filled alpine meadows. At the route's 11,000-foot high midpoint, passengers enjoy a view of the inactive Climax Mine with its terraced, open pit benches and gaping Glory Hole, a half mile-wide, thousand foot deep depression created by decades of large-scale block-cave mining.

Leadville took another step toward tourism in 1988, when the National Mining Hall of Fame & Museum, then a fledgling organization in its planning stages, was looking for a home. In open competition with other western mining towns, Leadville made an unbeatable offer: an in-perpetuity lease on a century old, four story, brick Victorian schoolhouse for a token annual fee. Today, the National Mining Hall of Fame & Museum attracts 32,000 visitors annually to view superb exhibits of gold, minerals, gemstones, mining art and artifacts, and to explore walk-through replicas of century-old underground metal and coal mines.

The museum's Gold Room displays gold specimens and artifacts from the 17 states that have hosted gold rushes, and gold specimens on loan from some of the nation's most prestigious museums. The Crystal Room displays include Colorado diamonds, rhodochrosite from the nearby Sweet Home Mine, rough and cut African emeralds, the 139 piece Anaconda Mineral Collection of museum or cabinet grade specimens from mining districts worldwide, and gem crystals from the collection of Keith and Mauna Proctor.

Another popular attraction is the old Leadville Mining District, which covers 20 square miles in the foothills just east of Leadville. Within this district, one of the West's biggest frontier-era mining graveyards, are the ruins of headframes, hoist shacks, ore bins, cabins, tramways, some 3,000 shafts, tunnel portals, and prospect holes, and 250 miles of flooded and collapsed underground workings.

Among the district's many old mines is the Matchless, once part of Horace Tabor's legendary silver fortune. Tabor purchased the Matchless Mine for $ 10,000 in 1879, after which it produced $7 million in silver. When Tabor died penniless in 1899, he left his second wife, Baby Doe, in poverty. Subsequent owners of the inactive Matchless, pitying the destitute and increasingly eccentric widow, allowed her to live in the mine's tiny cabin. Baby Doe lived at the

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A driller competes with hammer and hand steels in the drilling contests held each year during the Boom Days summer festival.

Leadville *from page 61*

mers for 36 years, often walking into nearby Leadville to trade pieces of high grade silver ore for groceries. In March 1935, neighbors found the frozen body of 80-year-old Baby Doe Tabor on the floor of her cabin. Today, the mine's surface facilities including the assay room, blacksmith shop, and Baby Doe's Cabin, are open to visitors.

The old mining district also has countless waste dumps where collectors can still find specimens of pyrite, galena, sphalerite, cerussite, calcite and dolomite along with a variety of other oxide, sulfide and carbonate minerals. Collectors should remember that mine ruins and dumps can be dangerous, and that many are on private property. The 'Route of the Silver Kings' brochure available locally explains the signs along the gravel roads that wind through the district. The roads are marked with numbered signposts which correlate to the brochure's maps and detailed historical information.

Even after 140 years of mining, the Leadville Mining District still contains a wealth of metals. Its identified resources include 28 million troy ounces of silver, 840,000 troy ounces of gold, and huge tonnages of lead and zinc. But that fortune, because of the lack of mills, smelters and railroads, coupled with high present-day labor, mining and environmental compliance costs, will likely remain in the ground forever.

In downtown Leadville, silver boom architecture continues to dominate historic Harrison Avenue. The 1879 Tabor Opera House, where Horace Tabor once applauded performers from his private box by tossing silver dollars onto the stage, opens for summer tours and stage events. Opera house owner and octogenarian Evelyn Furman is herself a Leadville legend. Evelyn is among the few remaining people who still remember seeing Baby Doe, the last living member of the "Tabor triangle."

Also on Harrison Avenue is the elaborately gabled, three-story 1881 Tabor Grand Hotel with its first floor shops and popular coffee house. Across the avenue is the restored, three-story 1886 Delaware Hotel, one of Colorado's most historic bed and breakfast inns. At the nearby 1878 Healy House, guides in period dress conduct summer tours through the richly appointed Greek revival style clapboard structure. Another popular nearby stop is the 1879 Silver Dollar Saloon, Colorado's oldest continuously operated saloon, whose walls are covered with relics and faded photographs of Leadville's past.

Visiting rockhounds always stop at the Rock Hat, which houses central Colorado's largest collection of quality minerals, including such locally mined species as rhodochrosite, galena on dolomite and golden barite.

The highlight of Leadville's summer is Boom Days, an annual festival held the first weekend of August. This three-day event features exciting mine drilling contests, in which miners from across the West compete with both modern mechanical rock drills and former era hammers and hand steels for big cash prizes.

Those planning a visit to Leadville should bank seasonally since the high elevation dictates the weather. The National Mining Hall of Fame & Museum is open year-round, but winter snows close many backcountry and mining district roads from November through April.

Even though its last mine has finally closed, Leadville, steeped in its rich history and heritage, remains one of the West's quintessential mining towns, and a fine place for rockhounds and mining history buffs to visit. For information call the Greater Leadville Area Chamber of Commerce at 719 486-3900 or 800, 933-3901, or check out the Leadville Web site at www.leadville.org.

The National Mining Hall of Fame & Museum in Leadville is one of the top public mineral displays in Colorado.

SCEPTERS at TRE

FIELD TRIP

A 4-inch cluster of skeletal Herkimer diamonds and calcite crystals from the collection of Michael Walter. (Photo by the author)

The mine entrance and shop on state Route 5S in Little Falls, New York

A New York Collecting Site Yields Unusual Herkimer Diamond Specimens

by Michael Walter

My first trip to the Herkimer diamond site in Little Falls, New York, called Treasure Mountain was in the summer of 1998. While collecting Herkimers in Middleville, my collecting partner (my father) and I met a young man who had helped manage the Little Falls location while it was initially being prospected. A group of individuals had recently purchased the 270-acre tract of fields and woodlands in the hopes of developing the area into another commercial site for collecting the beautiful quartz crystals known to most as Herkimer diamonds (Herks for short). We quickly accepted his invitation to go see the site firsthand.

The main reason this site intrigued us was not that it was new, nor that the owners were having good luck recovering quality crystals. What really attracted us was the discovery of sceptered Herks at this new site. We were new to the knowledge that Herkimer scepters even existed. My father and I, being avid field collectors and mineral hounds in general, found it strange that we had not seen a specimen at some point in our travels. The thought of such a crystal specimen drove us to abandon our diggings and go visit this location in Little Falls.

We arrived at what appeared to be a large nonworking farm south of the town of Little Falls, just off Interstate 90. From what we were told, this location and others in this general region had been producing quality Herkimer diamond scepters for many years. All had been well guarded secrets, however, until quite recently. At the farm, we all piled into a truck to continue across fields for approximately another mile.

A ledge exposure was being cleared by use of a track hoe at our destination. Large piles of fresh soil and rock were evidence that some serious work had begun. We inspected the pocket layer—often referred to as the table layer—and shared our thoughts on the site's potential. I believed from all I could see that the site would be a fine one. As with other collecting sites, the table layer was horizontal. The overburden that could be expected, even if the site were worked for decades, would be minimal. As the sun set over the horizon, I was left to speculate as to what these Herkimer scepter crystals would actually look like.

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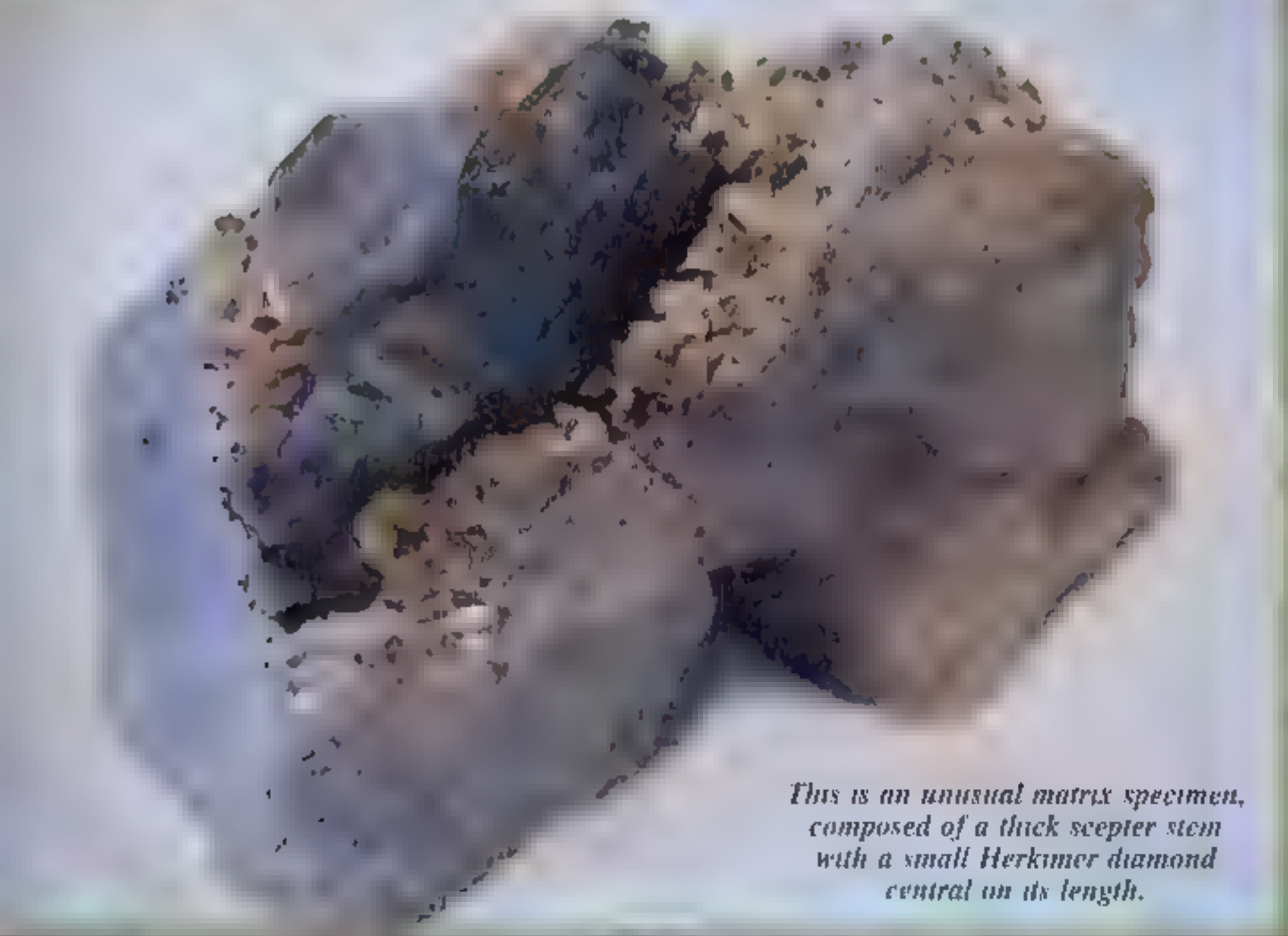
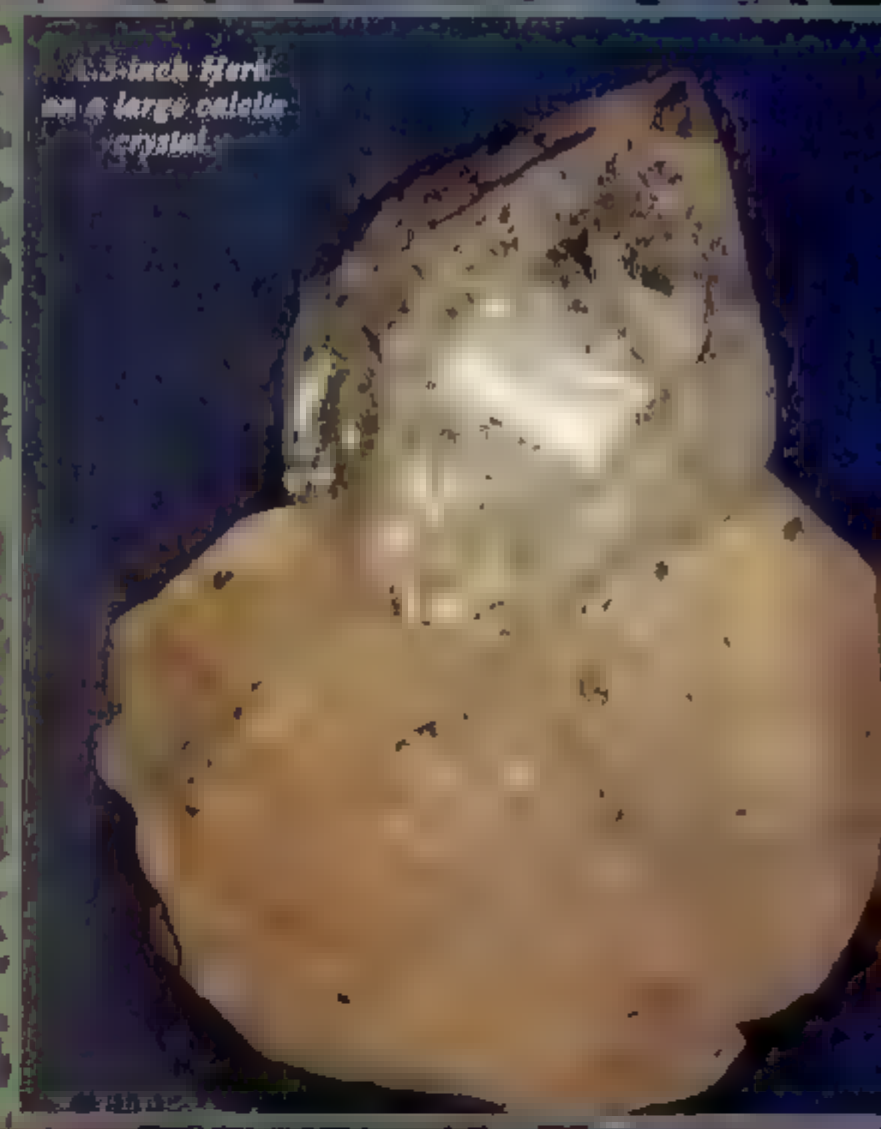
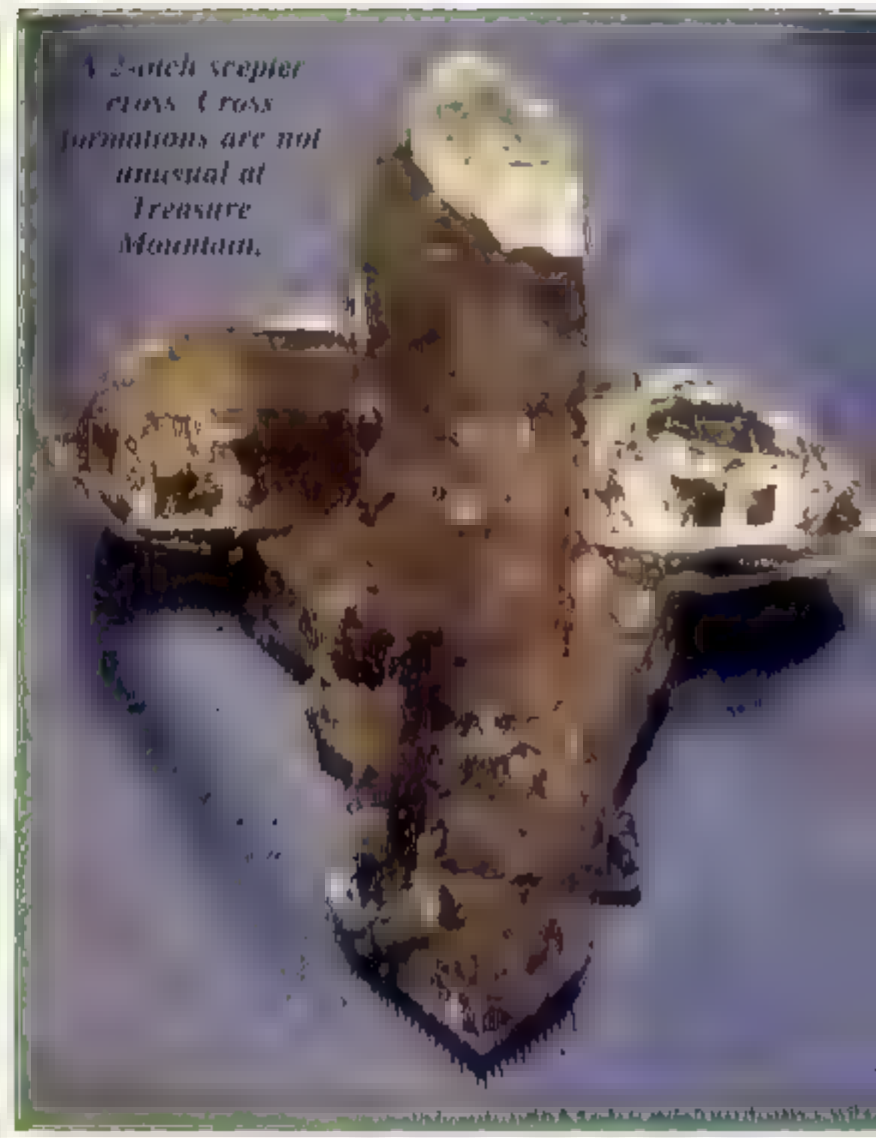
ASURE MOUNTAIN



This is an unusual matrix specimen, composed of a thick scepter stem with a small Herkimer diamond central on its length.





Scepters at Treasure Mountain *from page 64*

Though we were invited to return, the opportunity to do so was never realized until late in the fall of 1999. It was Oct. 15 when my father called and said he had found out the previous day that collecting at Treasure Mountain had begun earlier in the year. The site was open for business and was productive. My summer had been so busy collecting at other locations, doing shows, investigating new finds, and in September returning to my full-time teaching job that I had not followed up on the progress being made in Little Falls. We decided that the next day we would make our first trip to the site to collect.

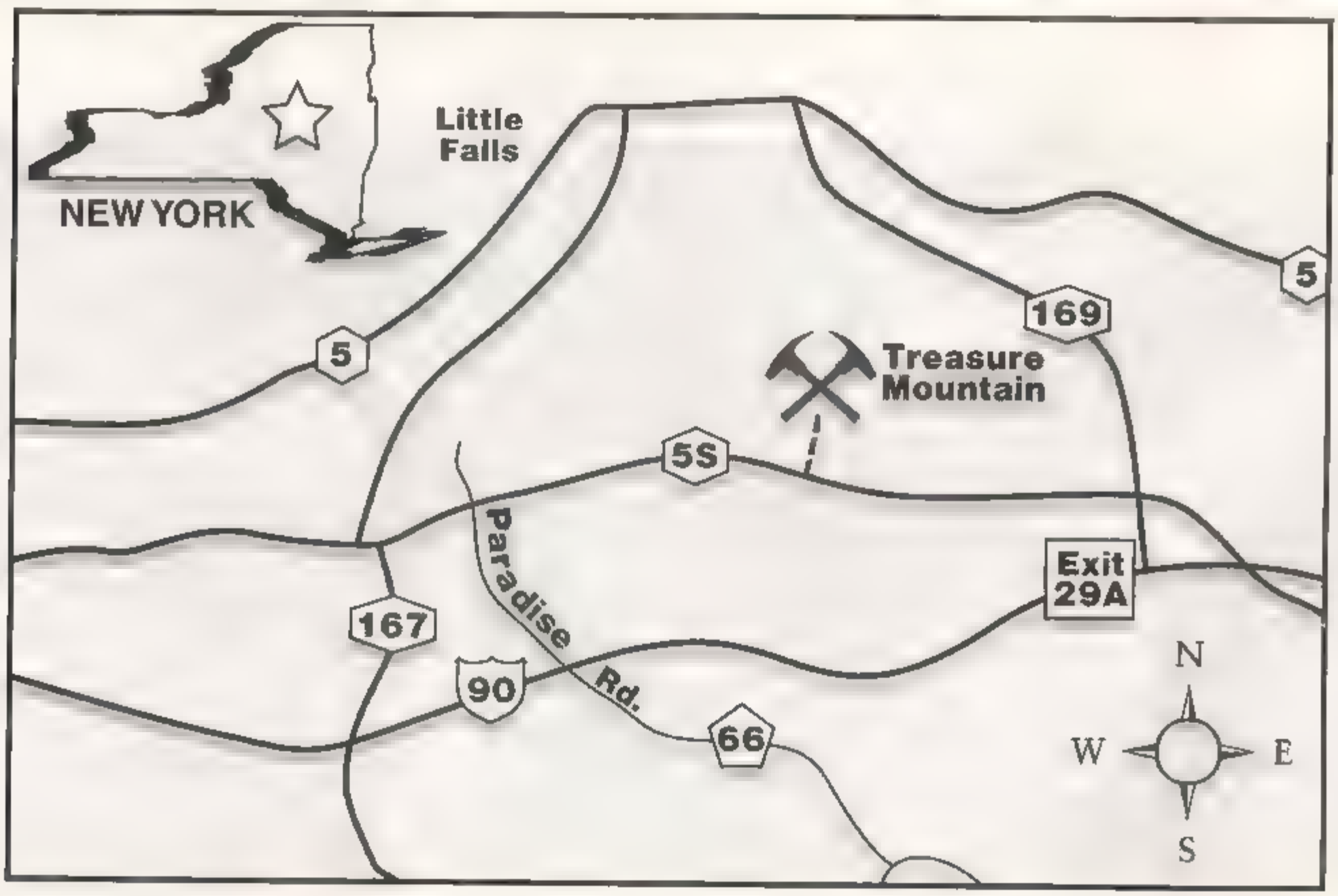
We arrived at the site at 7:30 a.m., no small task considering my drive was over four hours and my dad's almost as long. The site manager, Chris Phettepiace, took our $10 collecting fees and we inspected the cases of minerals on display in the shop. Most of the materials were from the mine, mainly crystals similar to those from other locations throughout the central part of New York, but also small scepters of quartz that made an immediate impact. These were the very first I had seen. The sceptered crystals were unlike most scepters I was familiar with. Dark anthraxonite included stalks terminated by clear, often skeletal, Herkimer diamond tips; they were both unusual and beautiful. Some were even doubly terminated, and were referred to as "dumbbells." There was a good selection of pieces to be had at the shop for $10 to many hundreds of dollars.

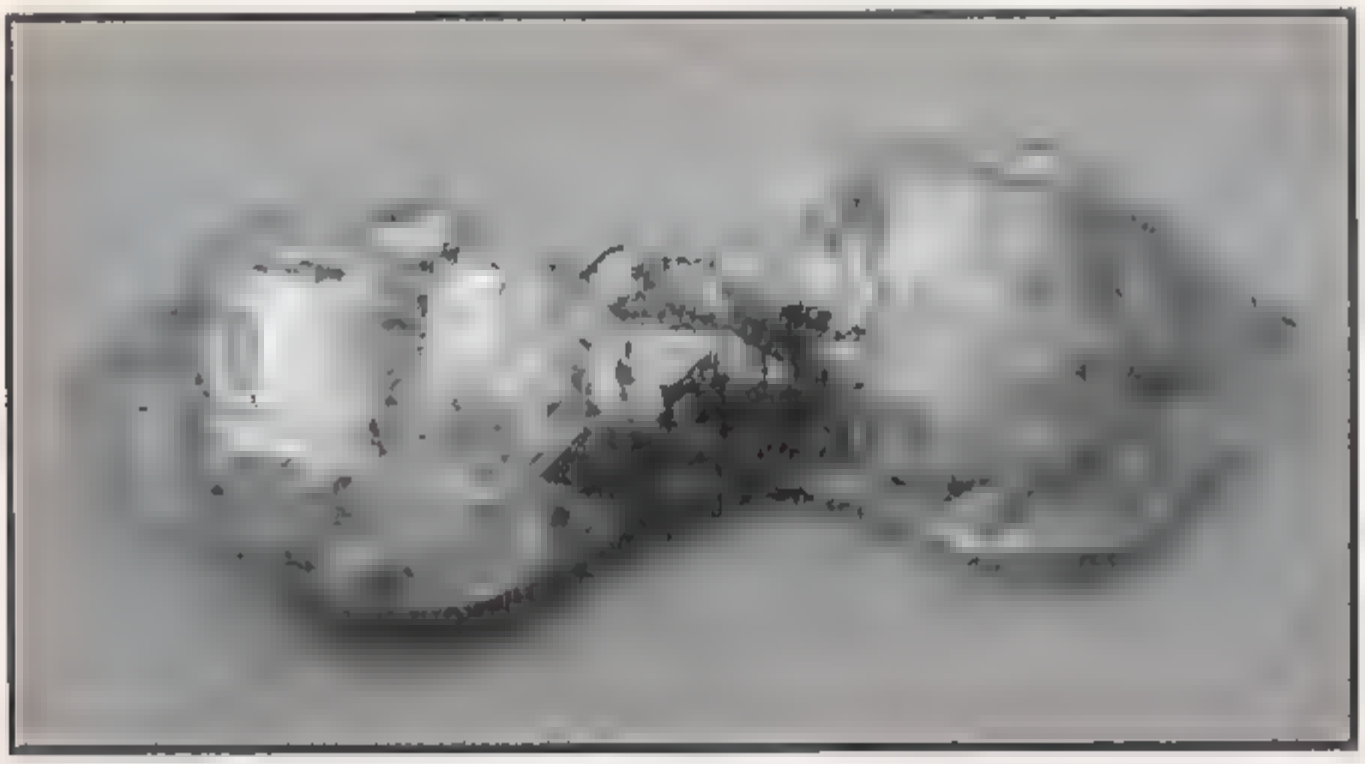
Since we wanted our specimens of these unusual crystals to be self-collected, we needed to get to work. By 8:30 a.m. we were at the ledge, where enormous amounts of digging had gone on before our arrival. A long section of ledge that looked at least 150 yards long was being worked along its entire length. A great deal of the overburden had been bulldozed away so that collectors would only need to remove 3 to 5 feet of rock to reach the clearly visible table layer. This was very exciting, considering how deep one has to dig at most commercial sites to reach this layer. At many it can exceed 10 feet, and in our claim at Diamond Acres it was well over 8 feet. This rock is often very hard and the less overburden you have to move the better. At Treasure Mountain, customers are allowed to use any hand tools they wish and can find as many pockets as they desire.

There was a knob that only rose about 2 feet of overburden and was approximately 6 feet long and 3 feet deep. No one was digging here, so this became our point of attack. For this type of digging, heavy tools are a great help. Overburden is not an overwhelming challenge to remove, the layers can be split off with a moderate amount of arm work. Wedges, spring steel, and good pry bars are excellent tools for this part of the job. But the layer of rock in which the pockets are found is nothing short of bulletproof. You can destroy a lot of good tools trying to establish a crack in this rock. We tend to use spring steel to expand, or make, cracks in this layer.

The first good chunk of table layer rock that we extracted revealed a small pocket. By small I mean around 8 inches in diameter and 4 inches in depth. As we were to find, this seemed to be more of an average pocket size in the area we had selected. The pocket contained numerous nice specimens. They appeared to be a cluster that had once been attached to the base of the pocket and were now scattered about freely in the open space. All of the crystals were in the 1- to 3-inch range, and there were about eight or nine total. They all had a thin coating of clay covering their surfaces. None looked broken or in any other way damaged. It was a great start.

As the day progressed, we began to realize how good the collecting here really was. At most locations we had worked in our 10 or so years of collecting Herks, we could usually find only one or two pockets on average per day. This is with two of us working very hard. By the end of the day in Little Falls, we had extracted five quality pockets, as well as numerous minor ones. It seemed that we could not remove a chunk of this table





Perfect crystal specimens, such as this beautiful 2¾-inch dumbbell scepter, can be hard to find.

layer without uncovering a pocket of some form. Most of the pockets contained diamonds. Once in a while, we would encounter a dry pocket – one containing no crystals – but most of these seemed to interconnect with another pocket which inevitably would contain Herks.

The real question was, where were the scepters? By noon we had worked several pockets and recovered many nice crystals, but none of them were scepters. These crystals were as good as or better than those from most sites I had worked in the past. The only notable differences were that these usually had more inclusions of anthraxolite and we encountered more skeletal crystals.

Shortly after lunch, I opened a pocket that ended up being split right down the middle. It was like breaking an egg for an omelet. The contents of the pocket emptied in front of me onto a flat dolostone slab. I inspected several nice crystals up to 3 inches in size and then quite unexpectedly, a small piece of clay and a small diamond came rolling out of the section of pocket still in the wall. The diamond clunked its way across the hard rock and came to rest beside its brothers and sisters in the wad of mud that I had been inspecting. My first thought was, 'That can't be good for the specimen!'

I had gone back to looking over the larger crystals for only a moment when it hit me that the roller didn't look quite right. I picked it up and immediately realized we had our first scepter. I guess I had been expecting something different – a dark stem with a clear termination, maybe even a dumbbell, or perhaps a matrix specimen. This was none of these. This little beauty was a clear crystal only about 2 centimeters in diameter with two small stalks of dark quartz, each with clear scepatered caps. It was a floater with no visible attachment points anywhere on its surface. In reality, it was a small, branching scepter specimen. How did this fragile-looking piece not broken on its two foot tumble across the rock platform? Sometimes it is better to be lucky than good.

After the 1999 collecting season, the staff and owners of Treasure Mountain encountered trying times. The city of Little Falls refused to grant the organization a permit to continue their collecting and commercial mine operations. The site was closed to the public and the collecting ended temporarily.

After a long hiatus, the Treasure Mountain Diamond Mine was granted a temporary permit to operate in the spring of 2001. At last, word was slow to get out. I arrived in May, and besides one other collector, had the place to myself. By Memorial Day weekend the flocks were arriving. Those who had been anxiously awaiting the reopening were happy to return to Treasure Mountain to collect Herkimer diamonds.

When they arrived, collectors found hundreds of feet of exposed wall rock that they could work. In some spots, the wall was excavated all the way down to the table layer, while in others the wall rock was upwards of 6 feet high. On average, there were about 4 feet of overburden to remove to reach the pocket layer. Compared to other collecting sites, this dramatically reduces the amount of work required to find quality crystals.

Many collectors, especially those with children, elect to break rock already removed by others instead of attacking the wall themselves. This method has been

continued on next page

extremely productive, leading to some of the best finds in the history of the mine. Simply cracking open rocks can reveal pockets passed by others.

On my first visit of the 2001 collecting season, I elected to attack several knobs of rock that stuck out farther than the rest of the wall. These knobs are usually left behind by other collectors because they are composed of the hardest rock found at the mine. Many collectors are not prepared with the proper equipment to tackle these areas, or give up when they encounter the extreme difficulties involved with breaking into this rock. Mine manager Carrs Phetteplace believes the best specimens are found in this "hard rock."

As we broke our way through the softer regions on the perimeters of a hard rock knob, we found the going quite easy. Even the table layer lifted and shattered with only moderate effort. Throughout this region, the pockets were larger and more spread out, and contained poorer-quality crystals.

Once we reached the knob itself, progress slowed to a snail's pace. This was the hardest rock we had encountered at Treasure Mountain. Even the layers above the table layer were dense and void of cracks. Eventually, we were able to set a large spring steel wedge below the table layer in an extremely narrow mud crack. Spring steel is simply car leaf springs cut down in size and ground into a wedge on one end. Once positioned, we took turns hammering the steel home with a 20-pound sledgehammer. This was slow going, but in time we secured a second and then a third wedge directly on the first. Soon, the telltale signs of cracking rock began to show. After swinging a sledgehammer for an extended period of time, it was relieving to finally see a major section of rock face release.

Once it was freed, we were surprised to see little in the way of pockets. A section this large (approximately 4 feet long by 2 feet deep) would normally contain several nice pockets. A demoralizing result to say the least. Several small pockets showed promise, however. They contained small, skeletal crystals and, to our surprise, lots of dark, powdery anthraxolite. The last section of this knob represented the last two-thirds of its total mass. We had a tough time getting motivated to tackle its removal late in the day, so we chose to continue our efforts the next morning.

On our third day, we again faced off with this hard rock knob and began setting steel wedges. Before too long, the entire section was broken loose as one massive 5-foot long by 3-foot deep by 3-foot thick chunk. No pockets were revealed behind the section, so we began breaking it up with chisels and sledgehammers. We found lots of smaller rock pockets packed with anthraxolite, several pockets I found the day before. Finally, we hit a larger pocket, approximately 10 inches long, 3 inches wide and 2 inches deep. This pocket was the best we would find on the trip. Five scepter specimens were removed, and all except one were between 1 and 2 inches in length. They had very short stems that were anthraxolite shrouded. The fifth was a smaller scepter, but it was on a dolomite matrix. All the hard work had finally paid off.

Impressive branching scepter clusters are another form of Herkimer diamond that can be found at Treasure Mountain. This specimen measures 2" inches.

Five Herkimer pockets are exposed by the removal of a 1-foot by 4-foot block of table layer at the Treasure Mountain Diamond Mine.

The matrix rock at Treasure Mountain is somewhat typical of those found at other Herkimer diamond mines in the area. Doubly terminated quartz crystals can be found as singles or groups both on and off the massive and crystalline dolomite matrix. They are excellently formed and make wonderful display pieces. The crystals range from almost invisible to many inches in size. Average-size crystals are from 1 to 2 inches long.

Enhydro varieties in the quartz seem to be more prevalent at Treasure Mountain than in other areas. Scepter crystals are the obvious variety being sought after,

but skeletal crystals, enhydro and other unusual inclusions such as goethite and pyrite are commonly encountered. Most crystals have black anthraxolite inclusions to some degree. These hydrocarbon inclusions impart uniqueness and character to the specimens from this site.

The calcite crystals from Treasure Mountain are often well formed and attractive. Though usually gray, they can also be various shades of yellow or white, or close to clear. Their surfaces are often frosted or etched, rarely are they smooth and of high luster. Clusters of calcites can reach sizes exceeding 6 inches in diameter and are usually attached to the dolomite matrix.

Combination specimens that include both quartz and calcite can be very interesting. The calcite forms after and sometimes partially or fully encases the quartz. It could be argued that some of the calcite and quartz combination specimens are the most attractive and valued specimens found at Treasure Mountain. They are not usually large in size, but are often unique in their form and crystal arrangement. Quartz can often be recovered by taking home the massive calcite found in some pockets and etching it away with mild acid to reveal the Herkimer diamond specimens hidden within. Scepter crystals can sometimes even be found using this method.

Locating the Treasure Mountain Diamond Mine is a simple task. Take exit 29A off Interstate 90 at Little Falls. Once you go through the toll booth, proceed down the hill and take the first turn north onto state Route 169. Follow this route for a quarter mile and then turn west onto state Route 5S. Approximately two miles farther along (almost all uphill), you will find the mine entrance and shop on your right. Here you must pay your collecting fees and receive further directions to the dig site on Fall Hill, which is located about one mile onto the property. (GPS reading N 43 01 degrees, 9 5 feet by W 074 50 degrees, 949 feet) at an elevation of approximately 780 feet. Camping on site is permitted. As yet, the facilities are primitive. In the future, running water and showers are to be installed.

As of this writing, fees are $10 for adults and $5 for seniors (over 60) and children under 12 years of age. Camping is $10 per party, per night. The Treasure Mountain Web site is www.treasuremt.com. Mine personnel can be reached by phone at (315) 823-ROCK. The mine is open seven days a week during the collecting season. It is recommended that you call ahead to be sure the mine is open before leaving on your collecting trip to this fantastic site.

The Town Built on URANIUM

Moab Owes Its Success to This Controversial Mineral

by Roger McPherson

Moab, Utah, was transformed by the uranium rush that took place in the southwestern United States during the 1950s. Now famous for its Colorado River rafting, canyon country four wheel-drive adventures, and mountain bike trail "hikes," Moab seemed crowded when Dale Edwards arrived in the mid-1950s.

"Uranium did a lot for this town." Edwards' voice echoed in the deserted offices of the old Atlas Uranium Reduction plant, across the Colorado River from Moab. "The uranium industry made this town what it is today. When I came here during the uranium boom, there was no place to stay. I lived in a camper on the river for 18 months until I got a place in town."

Yellow hard hats decorated a coat rack by the door. Seen through a smudged window, the beveled layers of soil covering the old tailing pond blended with the distant canyon walls.

"There were about 650 people in the mines and mill. Now there's just one—me. And when the Nuclear Regulatory Commission [NRC] trustee takes over, there'll be none. I came here and helped build the mill in 1955. I started as a laborer and cement finisher. When the mill started up in 1956, the Uranium Reduction Co. asked me where I'd like to work, and I said, 'The laboratory.' I was trained by the AEC in Grand Junction, and I took correspondence courses. Eventually, I became the radiation coordinator of the mill and mine."

Edwards showed me a long checklist he fills out for the NRC: air samples, radon gas, wipe tests, surface water samples, groundwater monitoring wells, soil and foliage samples, etc. On his shirt, he wore a badge that measured beta and gamma exposure, and on his belt was a box that took air samples.

"When Uranium Reduction was first built," Edwards explained, "Charlie Steen owned some 50 percent of it. Charlie got some backing and built the mill. He was real generous with his money. He was a good man. In 1962, Atlas bought the plant from him and Uranium Reduction. At that time, we had ore with copper in it. Our products were not only uranium, but vanadium and copper as well."

Edwards led me down an empty corridor past silent offices. "We shut down in March 1984. We had a lot of ore, but we couldn't make a profit," he said, and had me lift each foot so he could check my soles with a scintillometer and alpha meter.

"Just because we're down doesn't mean there isn't a lot of work to do. All of these checklist items are NRC license conditions. They have inspections at least once a year, and they can come in as many times as they want, unannounced.

We haven't had any serious [illegible] many years. In 1988, the NRC gave us the go-ahead for decommissioning and stopped the pond, but some valuonists wanted an environmental impact statement. I came at this year said there would not be a detrimental effect on the environment or human health.

"Still, a lot of environmentalists want the tailings ponds moved. I can't show you assays from uranium stations on the Colorado River above and below the mill and here's higher readings above it. After a thunderstorm it's 10 times higher. Uranium above the mill. There's a lot of uranium in this country. It outcrops everywhere."

After the big uranium prospecting rush of the 1950's, the United States experienced the Three Mile Island disaster and saw the movie "The China Syndrome" in 1979. Then came the end of the Cold War and ongoing protests against new nuclear power stations. The price of uranium declined. Health risks from uranium mining, tailings disposal and nuclear waste storage became issues. Ralph Nader founded the watchdog group Critical Mass and wrote *Un Master of Modern Energy* (1977). An industrial academic group at Massachusetts Institute of Technology established the Union of Concerned Scientists in 1969 and published *The Risks of Nuclear Power Reactors* (1977), *Rasmussen Was Wrong* (1980), and *Safe Second Try* (1987).

A car I rented from the Atlas car offices and a block up Center Street in Moab away from the small fleet of sport utility vehicles and mountain bikers on Main Street, I found the Dan O'Laurie Canyon Country Museum. The uranium funerary "Geiger Cake" containing about 75 percent uranium are displayed along with a Babbel counter. Early Geiger counters are scarce items. The history of uranium mining is explained and photographs capture the big operations. Standard's Big Buck Mine, Charlie Steen's Mi Vida Mine and the Atlas URECO Mine, where uranium ore was turned into enriched "yellow cake."

At a Moab Paints and Pebbles Club gem and mineral show at the Old Spanish Trail Arena, a co-prospector June Clevenger recalled the moment the Babbel counter went wild. She welcomed hoots at the event.

My ex-brother-in-law Gordon Babbel read about Geiger counters in a national mechanics magazine. He ordered one and when it came in the mail it weighed 860 pounds! By the time he died, he was making one the size of a cigarette package but one perfected the scintillometer. He mounted one on his airplane and he could tell where there was uranium.

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The Town Built on Uranium *from page 73*

Prospectors use either a Geiger counter or the more sensitive scintillometer. However, neither of these instruments distinguishes between uranium, thorium and naturally occurring radioactive K-40. In addition, surface weathering often reduces the radioactive response so pitting or drilling is needed to reach fresh material. Airborne radiometric surveys are useful, but ground follow-up must be done to determine whether uranium caused the anomaly.

Uranium was discarded in tailings during a vanadium and radium rush to the Four Corners area and the Colorado Plateau in the 1920s. Vanadium mills in Colorado and Utah were converted to extract uranium for the Manhattan Project in the early 1940s, and 1,000 tons of additional ore from the Belgian Congo were brought out of storage on Staten Island for constructing the atomic bomb. Controlled nuclear fission was demonstrated in 1942, and Hiroshima and Nagasaki, Japan, were destroyed a year later.

The Atomic Energy Commission (AEC) began a massive procurement program with guaranteed prices for ore and new discoveries. These price supports ended in the 1960s, however, when the AEC began buying only ore developed before 1958. By then, hundreds of deposits had been found, and the market was saturated with uranium.

At the Moab gem show, Jimmie Walker gave me his business card, which advertised "The Finest Utah Redwood." Wearing a belt made from petrified dinosaur bone and a belt buckle crafted by his son from moss agate and more bone, he looked every inch the prospector and rockhound.

"When this area got into uranium production," he told me, "I studied it and began staking claims and leasing them to companies." Now 71 years old, Walker knows these canyonlands well. "I came up with a few theories. I had a little 1954 Jeep. Later on, I got a four-wheel drive pickup that could carry more supplies. We'd have sleeping bags. Weather'd get real bad, we'd stay in the truck under a tarp. We would be moving around a lot.

"My first claim cost $2 to record it. Today, you got $140 per claim. They've destroyed the little guy. What you'd do is work on a lease—get a retainer royalty. I just never got enough claims into production. They found some pretty good uranium on my property, but the prices went down. Then came Three Mile Island, new information about the Nevada testing, and passage of the 1976 Federal Land Planning and Management Act. Little people can't survive."

"You gotta understand the local geology," Walker continued. "First, you look at the formations. The clay unit in the Morrison Formation is composed of volcanic ash. The theory is, the uranium originally came from the volcanic ash. Microscopic obsidian runs higher in uranium. When oxygenated water got on it, it leached out different minerals and freed the uranium."

We stood by the cases where deep-red chunks of highly agatized redwood were displayed. "Our local geology is the Paradox Basin. Two hundred to 300 million years ago it was an inland sea. Evaporation happened some 20 times, forming potash salts. When the sediments piled up, the salts flowed, affecting the surface, creating faults that made the Moab Valley, Salt Valley, Paradox Valley, Lisbon Valley. There were lesser structures that didn't collapse. All of these helped develop river drainages. On the north side of the Paradox Basin, the Uncompahgre Mountains are still coming up. Pressure made anticlines that eventually fell in, exposing outcrops for prospecting.

"My prospecting was done visually, working on why or why not a stream system went where it did." He rubbed his forehead and smiled. "Now, Charlie Steen was an oil geologist. He saw the relation between uranium deposits and oil deposits. He felt you needed to prospect around oil structures, like in Lisbon Valley. There were already some small mines there on the surface. He drilled into the Mossback section of the Chinle Formation."

Steen, an unemployed geologist from Texas, had figured the area around Moab had potential. In 1952, he staked 12 claims near other discoveries, but veered back from the usual target of the canyon's edge. His idea was based on the petroleum geology of anticlines as traps for fluids. He drilled into pitchblende, a dirty-gray area in the sandstone and conglomerate. His shaft put in on a shoestring and one drill target, found black ore running 0.33 percent to 5 percent uranium after 68 feet of tunneling.

"Charlie Steen packed them drill cores around in his pickup for days before he had a friend put a counter on it," Walker recalled. "You can't eyeball it, you need a counter to see the grade. A lot of people had a scintillometer because it was more sensitive."

Steen's highly publicized fortune was the kind of success story the AEC needed. Steen started the uranium processing mill near Moab, and became the largest employer in the county. In 1962, he sold his holdings for $10 million, but by 1969 he was bankrupt, because of his lavish spending, his generosity, litigation costs, and tax accounting problems with the IRS. His story is told by Raye Ringholz in *Uranium Frenzy* (1989).

Nuclear power plants that produced steam to generate electricity. 1 pound of uranium generates the heat equivalent of about 8 tons of coal—moved from the experimental stage to commercial operation in the 1960s. Alvin Weinberg, former director of the Oak Ridge National Laboratory, wrote in his autobiography, *The First Nuclear Era* (1994), "We all wanted to believe our bomb-tainted technology really provided humankind with practical, cheap, and inexhaustible energy."

As part of the optimism of the time, in 1974 the AEC projected that 50 percent of the world's electricity would be from nuclear power by the year 2000. However, by the end of 1993 Canada's 22 reactors

Just outside of Moab, the Atlas Minerals uranium processing facility waits for final reclamation. Only the empty offices and the capped tailings pond are left. (Photo by the author)

supplied only 17 percent of that country's electricity, and in 1974 the United States had 109 nuclear power stations supplying only 22 percent of its electrical power.

Weinberg felt that the four big nuclear reactor vendors—General Electric, Westinghouse, Combustion Engineering, and Babcock and Wilcox—offered reactors at unrealistically low prices and built large reactors before lessons from smaller reactors could be incorporated into their new designs. Maintenance, expensive components, high construction costs, government regulations, and the unresolved issue of nuclear waste storage burdened the nuclear energy industry.

Developed countries without low-cost coal resources—France, the United Kingdom, Japan, South Korea and Taiwan—embraced nuclear power. According to Weinberg, these countries "kept the nuclear torch burning brightly while it gradually dimmed in the United States and other participatory societies."

Uranium is widely dispersed in the natural environment, occurring on average from 1 to 2 parts per million (ppm) in the earth's crust and 4 ppm in granitic rocks. Of several uranium minerals, only thorium and uranium are found in quantity in nature. Uranium originally comes from magmas and igneous rocks, primarily granites. As the magmas crystallize, accessory minerals such as zircon, monazite and apatite take up uranium. Late magmatic products such as pegmatites and veins contain uraninite in the form of pitchblende.

"I had some pitch[blende] in the office once," Andy Harman, a Canadian mine maker, recalled. "Just a hand[ful] from the Yukon Territory. I turned the scale on and it just roared." Even outside the office on a window ledge, it sent the meter dancing, and he had to dispose of it.

Some uranium is deposited as film on rock crystals, which readily oxidize and release water-soluble uranium into solution in surface and groundwater, where it adheres to clay minerals and carbonaceous material. The resistant accessory minerals are washed into sedimentary beds, especially sandstones. Freshwater streams and stream channels that were interbedded with mudstone layers provided ideal beds for fine-grained uranium minerals, and deposits formed as uranium-rich minerals moved through the pore spaces in the host rock, replacing plant fossils and sand grains and cementing the minerals. Minerals that are commonly associated with uranium include copper, vanadium, selenium, molybdenum, lead and manganese.

Granitic sources of uranium were often remote from the sandstone and mudstone beds, and the method of deposition wasn't well understood for years. Flat-lying bodies of uranium were found parallel to the bedding, usually in just one stratigraphic layer. Broad, shallow basins entrapped the uranium-rich water and sediments. Stream and groundwater normally carry uranium to the ocean, where it precipitates in muds containing organic material or in phosphates.

Uraninite, an oxide usually seen as pitchblende, and coffinite, a silicate, are the most common primary uranium minerals. Both are black and occur either where they have replaced fossil wood and sandstone, or where they are disseminated in the sandstone pores. Pyrite or marcasite is found in nearly every unoxidized uranium deposit in sandstone. The reducing environment of the groundwater traps causes ferric oxide to change to ferrous oxide, forming pyrite.

A variety of secondary minerals are created from the primary minerals and from migrating ground and surface water. Most people recognize the yellow vanadates, carnotite and tyuyamunite. Navajo and Ute Indians were able to lead geologists to some outcrops of red vanadium and yellow carnotite because they used the colorful minerals in ceremonies and artwork. There are many uranium arsenates, carbonates, phosphates and silicates. 30 new uranium minerals were found in the 1950s.

Sandstone-hosted uranium deposits are related to the flow of mineralizing fluids through the host rock. The most common form is a "roll front," a stage roll that is C-shaped in cross section. Other deposit shapes that occur are pods, blankets and logs. Mineable ore grades in the Four Corners area were from 0.1 percent to 1 percent uranium oxide. In contrast, ore from Canada's Athabasca Basin mines begins at over 1 percent uranium, and some new mines average 4 percent uranium.

Key features of productive ground are thick sandstone beds, red sandstone turning to light shades of brown, yellow, gray, green or white, anomalous radioactivity, carbonized plant remains, colorful secondary minerals of iron, vanadium, copper, molybdenum and cobalt, and a mix of sandstone and mudstone rather than clean sandstone.

Uranium deposits form in the thicker and more permeable parts of sandstone beds. A sandstone stratum of 100 to 1,000 feet thickness might contain an ore-bearing layer less than 100 feet thick, but sandstone less than 40 feet thick generally is not favorable for large ore bodies. The many colors that are typical of a uranium deposit result from the reduction and oxidation of the secondary minerals in the sandstone and mudstone, and may extend well beyond the deposit.

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Approximately 30 percent of uranium mines are open pit. However, underground mines have significant health hazards because of radon and particles coated with uranium minerals. Colorado Plateau mines often hired Native Americans for underground work, and in the early years of mining, health dangers were not recognized or understood. Peter Eichstaedt exposed the long-term health problems that Native American miners are now having in his book *If You Poison Us* (1994). Steve Voynick's *The Making of a Hardrock Miner* (1978) described the dangers of mining uranium in unconsolidated ground and the sorry state of early inspections of mines for compliance with regulations.

Consumer advocate Nader divided the use of nuclear power into the "front end"—mining, milling, conversion into uranium fluoride gas and enrichment of uranium, and fabrication into fuel—and the "back end"—the treatment of nuclear fuel once it's removed from the reactor—of the fuel cycle. Nader pointed out the worst hazards of mining: that radon daughters (Polonium 218 and 214, and Bismuth 214) resulting from poor ventilation remain suspended in air or on dust particles and cause lung cancer, and that contaminants from tailings piles pollute groundwater, and poison plants and animals.

Such concerns about mine safety, environment and health have led to stricter regulations and better monitoring. New mines now must carefully plan tailings disposal, underground mine ventilation, and mine reclamation. Because of the high uranium content in the ores of the Saskatchewan mines, Cogema Resources has developed special remote underground mining techniques. The area to be mined is frozen, and high-pressure water is used to cut up the ore body and pump it out.

To visit a uranium mining area, I drove 30 miles south of Moab, where I spotted a modest sign reading "Lisbon Valley Industrial Park." A paved road led into picture-perfect canyonlands. Off one road were UNOCAL's helium, propane and nitrogen fields. Union 76 had several more small wells tucked into the canyons. I went along the straight Charlie Steen Road for about six miles until it wound into a narrow streambed. The road got rougher as I ran into spring run-off gravel and sand. When I spotted a mine dump with a train of abandoned ore cars off to one side, I parked and began to walk up to the rim.

The favorable oil and gas structures in the area and the Big Buck Mine up on the rimrock were clues that Steen had followed in his search for a uranium trap. In a low saddle that was covered with sagebrush, I saw cleared areas and a caved-in mine entrance. Steen's Mi Vida Mine was an extraordinarily rich discovery. He brought his family up here while he drilled, and they shared the loneliness and deprivation of living so far from town. Now the area has been completely restored, and no sign of uranium tailings remains.

Aside from the Colorado Plateau deposits, other important sources of uranium include veins, the paleoplacers of South Africa, the strata bound Olympic Dam deposit in Australia, the rich sedimentary deposits in Saskatchewan's Athabasca Basin, and the Elliot Lake Blind River paleo-conglomerates of Ontario, Canada. In the early years of production, uranium came from nickel-cobalt native silver veins in Czechoslovakia, the Belgian Congo (now Zaire), and Canada's Great Bear Lake. These hydrothermal veins contained uraninite (mainly in the form of pitchblende), davidite, brannerite and coffinite.

South Africa's Witwatersrand, or Rand, has produced uranium as a byproduct of mining gold from cemented conglomerates in which uraninite and gold are closely associated. In a similar type of deposit, Canada's Blind River-Elliot Lake Precambrian river channel conglomerates, north of Lake Huron, contain uranium, thorium and rare earth minerals. Though the 11 mines exploiting this 30 square mile Canadian uranium field are now closed, the potential for other deposits remains high.

The 1975 discovery in South Australia of the Olympic Dam copper-uranium-gold-silver deposit has added enormous reserves to the world's uranium supply. Extending over 15 square miles and with a vertical thickness of mineralization up to 1,000 feet, this sediment hosted deposit contains an estimated 2 billion metric tons of 1.6 percent copper and 0.06 percent uranium.

Canada leads the world in uranium production, and all of that comes from Saskatchewan. Discoveries made in northern Saskatchewan's Athabasca Basin since 1968 make this one of the world's premier uranium environments. Radioactive boulders led geologists to uranium source rocks. The enormous McArthur River and Cigar Lake deposits average 14 percent uranium. Formed in a sedimentary basin, the uranium was apparently leached from sandstone and granitic sources, transported through permeable beds, and precipitated in reducing environments. Cameco Corp. and Cogema Resources (a subsidiary of Paris-based Compagnie Generale des Matieres Nucleaires), which have their head offices in Saskatoon, are the majority owners and opetators of many of these mines.

On a typical sunny day in Moab, I met Verle Green outside the trendy Moab Diner, and he told me about working in the uranium mines. "I started out in 1954 in a little mine in Colorado on Tenderfoot Mesa. I came over here to La Sal to work for the Hidden Splendor Mining Co., and I worked at the Ike Nixon Mine. They got more high grade ore out of that than any mine in the area," he recalled.

"I worked at all the mines. I quit in 1961. I drilled, blasted and ran equipment underground. We didn't use ear plugs. We had respirators, but they'd plug up." He put out his cigarette and held dressed it down to nothing. "A mine is as safe as you make it," he pointed out. "Main thing when you went in—test the roof, bar down loose rock, and get rock bolts in."

Green had been a deputy sheriff in San Juan County, Utah, had worked in the oil fields as a roughneck and roustabout, run rafts on the Colorado River, guided four-wheel-drive back-country tours, and worked in the Grand Canyon on the mule rides.

"I was what they called a 'contract miner.' We had a guaranteed day's pay, but we could double our wages. I only spent seven, eight years in it. I've got friends, fellows I worked with, and a lot of them are gone. They all developed problems over the years. Many of them got silicosis, which turned into lung cancer and pulmonary fibrosis. When I quit in 1961, I had more seniority at Atlas Corp. than anyone on the payroll. Yeah, I loved it. I would've stayed, but I got bronchitis from the diesel fumes and dust. It probably saved my life.

"Back in the 1950s, Moab was booming. Everybody had jobs, new cars. It grew overnight to about 5,000. After Charlie Steen made his big strike, there were promoters, claim stakers—everybody was out to get rich."

He shook his head. "All we got left is tourism. People coming in here are buying up property. People are always getting lost in the canyonlands. They have more search-and-rescue in this county than anyplace in the U.S. The mining companies are environmentally conscious, but uranium here is shut down."

Meanwhile, new discoveries and increased production in Canada have made that country a world leader in uranium mining and nuclear technology. Demand for uranium is rising. Even though there are no new nuclear power plants being built in the United States, most of the electricity in France and the United Kingdom is now produced using nuclear power. Is the world ending an experimental phase and entering a new nuclear era, a post-Chernobyl world in which uranium and nuclear power have come of age?

ROCK SCIENCE

by Steve Voynick

Prospecting by Infrared

A new prospecting tool enables exploration geologists to perform mineral surveys that precisely identify the surface minerals present on hundreds of square miles of land. Such detailed surface surveys once took years to complete, but today's exploration geologists perform the same work in only a few days without ever setting foot on the land, thanks to a state-of-the-art technology called infrared hyperspectral imaging.

Until the middle of the 20th century, searching for mineral resources was a hands-on job in which prospectors and exploration geologists burned a lot of shoe leather collecting and identifying rock samples. But after World War II, the emergence of geophysical prospecting that employed magnetic, electrical, gravitometric and seismic methods began making the job a lot faster.

An even bigger advance in mineral exploration was the introduction of infrared remote sensing — the use of infrared radiation to acquire information about distant objects without direct physical contact. Infrared is invisible electromagnetic radiation with wavelengths ranging from 0.7 to 1000 microns. It lies between the visible and microwave portions of the electromagnetic spectrum. Because infrared penetrates atmospheric moisture far better than visible light, it has applications in everything from night-vision instruments, astronomical and aerial photography, and industrial and military heat sensors to more familiar remote-control devices such as television tuners and garage-door openers.

Infrared remote sensing was introduced in 1970, after scientists learned that all materials reflect infrared radiation in a unique and identifiable "signature." The first infrared remote sensors detected, measured and interpreted the reflected energy of a single infrared wavelength, and displayed the data as a simple image.

By 1980, multispectral remote imaging used from both aircraft and satellites, combined 12 infrared wavelengths into more complex images. Computer analysis of multispectral Earth images could differentiate between gross classes of vegetation, conifers versus deciduous trees, and even between basic rock groups, such as those composed primarily of silicate or oxide minerals.

Advances in the sensitivity and wavelength specificity of infrared sensors, as well as in computer technology, have now led to the development of hyperspectral imaging, which combines reflectance data from hundreds of infrared wavelengths into a single, highly complex image. Employing as many as 512 infrared wavelengths, hyperspectral imaging is capable of remotely and precisely identifying many organic and inorganic materials.

While multispectral imaging could only identify general rock groups such as silicate based rocks, hyperspectral imaging can identify such individual silicate minerals as quartz, orthoclase and plagioclase feldspars, nepheline, biotite and muscovite mica, and tremolite, actinolite, and can even differentiate the end members of the tremolite-actinolite solid solution series.

Hyperspectral imagers, which resemble large aerial cameras in appearance, cost about $3 million and are used from aircraft and satellites. In operation, they are cooled with liquid nitrogen to -273 degrees F, a near superconducting temperature that maximizes the sensitivity of the infrared sensors. A conventional lens first focuses the image on an array of thousands of tiny crystal prisms, each of which produce a single pixel in the final image. These prisms break the light down into 512 wavelengths, which are measured and digitally recorded by ultrasensitive infrared sensors.

In mineral exploration use, hyperspectral infrared imaging is most effective on barren land devoid of vegetation, but it is also being adapted for use in areas of dense vegetation. Geobotanists have learned that the foliage of certain plants growing in specific mineral environments develops identifiable spectral-reflection characteristics. Geobotanists are now compiling databases that will enable them to use hyperspectral imaging to "prospect" various ecological life zones, including forests, grasslands, jungles and tundra, to determine the nature of the mineral environment of the soils in which the vegetation grows.

Hyperspectral imagers and the requisite digitized geoscientific databases are already available to mining and exploration companies on a pay-per-use basis. Advanced hyperspectral-imaging systems will soon employ 1,024 individual infrared wavelengths and provide greater spatial resolution, with individual pixels representing just 1 square meter of the Earth's surface.

While infrared hyperspectral imaging will not render rock picks and core drills obsolete, it will certainly identify the best places to use them.

by Curtis L. Handy

Lowly, abundant jasper is at once humble and special; common, yet exotic; plain and simple, but often so colorful as to be astounding! Its range of color and pattern is amazing. Pick any shade or hue of the spectrum, any shape or structure, and you'll likely find it, not only as a single color or pattern, but in a multitude of combinations: in narrow stripes, wide ribbons, globs and blobs, mixed in swirls, brecciated, as pictures and scenes, orbicular/concentric, and in countless combinations thereof. It's a technicolor kaleidoscope in every nuance!

The name "jasper" is derived from the Latin *iaspis*, which corresponds to the Persian *iashm* and *jashp*, as well as the Assyrian *ashpu*. Jasper has been used since ancient times. It can be described generally as a type of massive (as opposed to nodular) deposition of cryptocrystalline, dense quartz containing rather large amounts of included materials and minerals, chiefly iron oxide (20 percent or more). The coloring agent in reddish types of jasper is typically finely divided hematite, and in brown and yellow types, generally goethite. Clay and aluminum also act as coloring agents, as do other minerals and materials. Brick red seems to be jasper's most common color.

Furthermore, jasper can be of sedimentary or metamorphic origin and occurs (in part) as very extensive beds or formations, which can be a factor in identification. Metamorphic jasper's microstructure is usually grainy (not fibrous) and may be the result of recrystallization of originally fibrous or spherulitic material, according to my research.

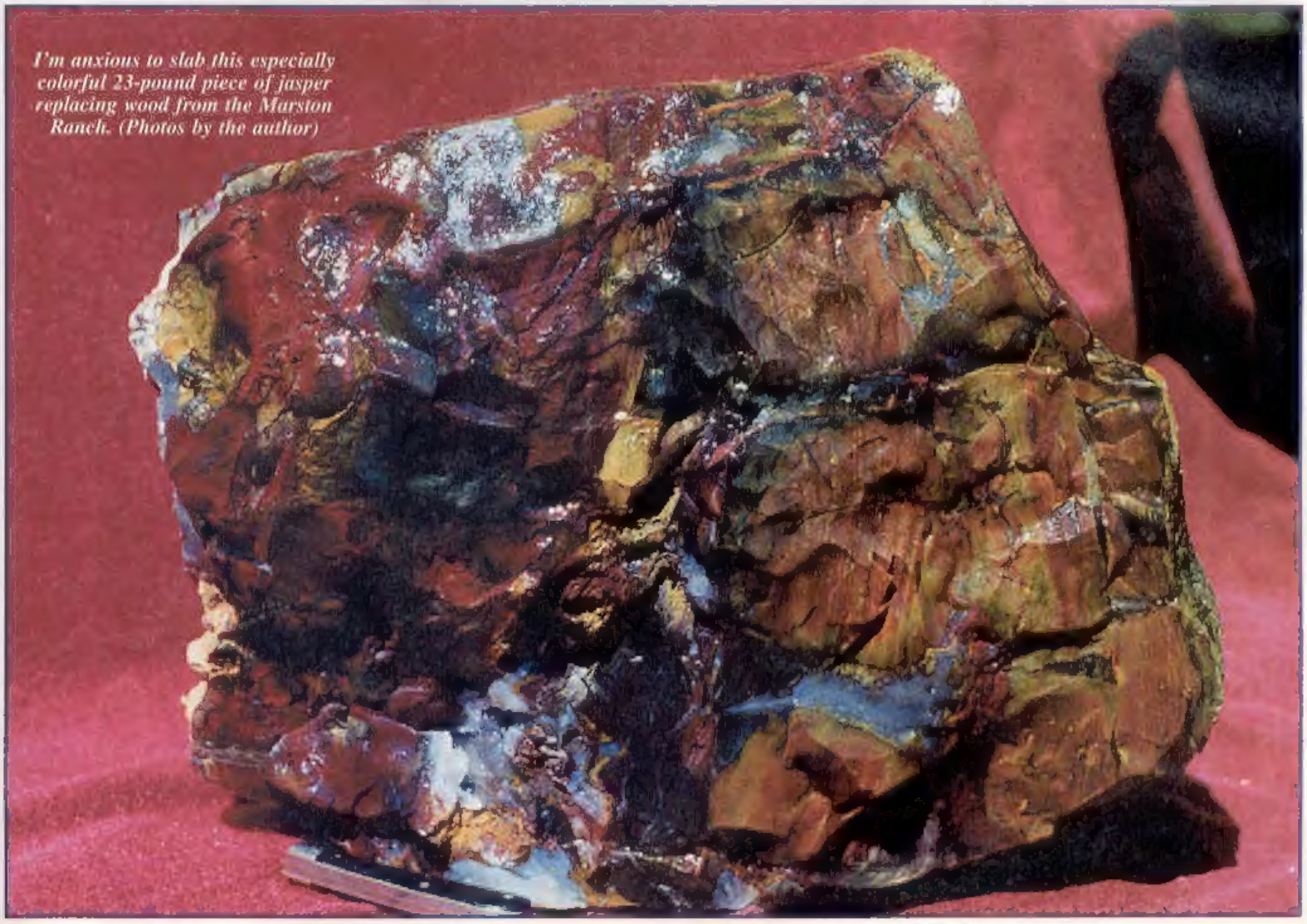
continued on next page

These jasper arrowheads and assorted flakes and pieces were collected from Oregon ranches.

Metamorphic yellow-gold jasper from Wyoming has a shiny black hematite banding. This piece weighs more than 200 pounds.

ENJOYING JASPER

I'm anxious to slab this especially colorful 23-pound piece of jasper replacing wood from the Marston Ranch. (Photos by the author)



Enjoying Jasper *from page 81*

As we know, jasper is a very common and widely distributed material. Perhaps its abundance prevents it from being held in higher esteem; it is found almost everywhere. It is a member of the quartz family, and is listed as a tectosilicate, which refers to its atomic structure. It has a chemical composition of SiO_2, the same as agate. Chalcedony is the slightly altered form of "crystal" quartz and forms in fibrous micrograin structures, rather than the familiar terminally pointed "rock crystals." It has a Mohs hardness of about 7. The quartz family tree generally reads: quartz (crystal), chalcedony, agate, jasper, flint and chert.

Primitive men, the original rockhounds, were not familiar with the chemical makeup of rocks, of course, but they still had their favorites, of which jasper was one. Flint, jasper and obsidian were the three most popular materials for tool making and survival. They were hard, tough, conchoidal, readily available, easily identifiable, and even pretty. Picture groups or individuals collecting at an exposed ledge, or stooping and squinting over a jasper-laden gravel bar, searching out just the right type or color. As with rockhounds of today, exclamations of approval or discovery would probably have been heard when suitable pieces were found!

SiO_2 is a deceptively simple chemical formula, able to produce not only jasper, but an entire family of complex and diverse quartz materials for rockhounds to enjoy. Jasper is variable in quality, full of impurities, included with myriad minerals and sediments, and prone to pits and pores. That's not exactly a ringing endorsement, but most collectors would agree that it is a truly remarkable and striking gemstone material.

Just as every diamond is not a gem, every piece of jasper is not common. The truth is, there are some very prestigious and highly regarded jaspers. The much sought after and highly valued Bruneau jasper from the steep canyon walls along the Oregon-Idaho border comes to mind. It fetches a pretty price, even in the rough. You can often see it used in unique, expensive, hand-made jewelry pieces. It is appreciated for its rich, concentric shades of earthy browns and creams.

Owyhee picture jasper is another quality stone from the same general area. More varied in color and pattern, it is valuable and readily recognized by the practiced eye. Still another is the justly famous Idaho Willow Creek jasper. Like the above-mentioned jaspers, it is especially smooth, hard and clean—almost porcelainlike. Pastel shades of greens and browns dominate this material.

While we are discussing jaspers from the Northwest, let's not forget Biggs jasper from the Columbia River area of Oregon. It was uncovered in a road cut years ago. Beautiful shades of rich

Rockhounds at the Marston Ranch gather to inspect colorful pieces collected from the pit area behind them.

chocolate brown forming circular, flowing patterns often make striking pictures and landscape scenes. The less common Biggs Blue is much sought after, too, and is now much harder to find.

Poppy jasper (notably from India and California) is also a popular form of this so-called plain and common stone. It's enjoyed for its orbs of reds, yellows and oranges. I expect almost every rockhound owns, or is familiar with, some popular form of this chalcedonic quartz. It is available in nearly every state, and especially here in the West.

A fellow rockhound, Loren Pine, and his wife, Bessie, live not far from me. They are retired now, elder statesmen of the hobby; he is in his 90s and she is in her 80s. For 20 years, during rockhounding's heyday, their motorhome was a familiar sight in the western states and at rock and gem shows. Their tales of discovery and the wonderful collection in their Rock & Leather Shop are most interesting and enjoyable. There are great specimens of jasper from many western states and, remarkably, Loren remembers clearly how, where and when each was collected. One of Loren's favorite stones is Montana dry head agate. Many truly outstanding cut and polished specimens are displayed in their showroom.

Much of the most colorful and varied jasper in my collection came from the Marston Ranch in the Madras/Ashwood area of Central Oregon; beautiful high-desert country just east of the snowy Cascade Mountain Range. The collectible rock on this 25,000-acre ranch is actually jasper replacing wood. Almost every piece is an individual universe of color and pattern. Pieces collected only yards apart are likely to be totally different! Last year's rock finds were very different from those collected in 1999. What minerals must have been present to dissolve and percolate through the broken bits of basalt and layers of ash to render such gorgeous colors?

Multicolored jasper is a common petrifying agent of wood, as exemplified by the Marston Ranch material. Jasper is also often laced with small veins of chalcedony and may be found as breccia, re-sealed by some variety of quartz. This is often seen in wood. Large amounts of fibrous silica may be present in jasper, and thus it can grade into chalcedony and its subvarieties. Indeed, silica seems to grade rather capriciously into one branch or another of the quartz family tree.

I enjoy photographing some of the more outstanding jasper pieces I've gathered on field trips or acquired here and there. Try photographing (or have a photographer do it) and labeling some colorful samples for framing. A group of four bright 5x7 photos in a 16x20 matted frame looks great on the wall. It's a conversation starter almost every time and always of interest to fellow rockhounds!

With that thought, some special jaspers from previous collecting trips come to mind. Several years ago, a friend and I enjoyed extracting some exciting multicolored jasp-agate from some shallow finger-veins trailing down a steep slope in the Western Cascades in Oregon, not far from my home in Roseburg. It came in lots of colors—bright and bold reds, greens and golds—and some of the material was nicely brecciated. It is still some of my favorite material. Four matted and framed photos hang on my office wall.

My uncle and I found a very large, strikingly red jasper boulder weighing about 80 pounds on an Umpqua River gravel bar just miles from my house some years ago. It makes a nice garden rock, since it's too big to cut without breaking it up. Some nice cream-colored agate veining is visible. That makes one curious about the interior.

An outstanding specimen, a nearly 200-pound boulder of banded gold jasper and shiny black hematite, was picked up by my brother while hunting in Wyoming. A low, rolling ridgetop was, he said, "virtually covered with the stuff." Sadly, he returned with only a fist-size piece and the very large boulder. I tumbled some pieces from the small chunk and the polish was excellent, with no telltale lines visible between the black and gold banding.

Some additional research indicated that the big, banded hunk of rock he found in Wyoming, occurs in "Precambrian iron formations of the Lake Superior region, in India, and other locations," and is referred to as jaspilite. By any name, it makes a great-looking rock!

I noticed an interesting bit of information in the *Audubon Field Guide* concerning chert formations. It says, in part, "It appears some Cherts have been formed by precipitation of silica from sea water. And it commonly occurs in masses ranging in size from nodules, to formations reaching thicknesses of 900 feet or more ... as in the Coast Ranges of California and Oregon." That would be some deposit to chip away on! The Coast Range mentioned is practically a stone's throw from my back door. Perhaps a search for its specific location

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calls for a field trip.

Madras, Oregon, is a great location for rock—perhaps not chert or jaspilite, but I look forward each year to joining the Madras-based field trips held by the All Rockhounds Pow Wow Club of America during their annual 4th of July Meets. They are doing such a great job, along with the local area ranchers, in making some wonderful material (agate, jasper, petrified wood, thundereggs, and the like) and dig sites available to rockhounds. I understand they have several new collecting sites lined up. I hope at least one of them includes some tantalizing new jasper!

Rock shows have also been the source of some nice jasper for me in the form of slabs. I make it a point to purchase a couple of "souvenir" slabs from each show I attend, especially if it's some well-known jasper I've heard or read about: Biggs Blue from Oregon, Stone Canyon from Utah, and Burro Creek from Arizona.

Recently, a nice windfall of rough befell me when a friend purchased a rental home. The garage in back of the house was piled high with boxes and stacks of all manner of rock: miscellaneous river cobbles, some nice obsidian (both black and mahogany), petrified wood, and good ol' jasper mixed in. Some really nice pieces emerged; I have no idea where they came from, but the friend was happy for me to haul off what I wanted. Rock for me, and a clean garage for him! Just a few weeks ago, I was digging through some of it for a piece to slab. Two pieces of jasper turned out to be wood replacement, one with lavender and orange hues, the other with agate and jasper in wood tones. They resulted in some nice, new slabs.

Many states seem to have at least one type or form of jasper of merit. If you attend rock shows, I'm sure you've noticed some special and spectacular pieces of jasper made into jewelry, or painted on, or fashioned into some form or another. Perhaps "lowly" jasper is not so mundane after all and deserves more attention and appreciation.

An interesting story comes to mind about a side-trip to the Polka-Dot Agate Mine during the July 2000 Pow Wow in Madras. Polka-Dot material is well known, so when I noticed the "Mine Open" sign along the road to Ashwood (north of Madras, off state Highway 97), I decided to stop in for a look and collect some Polka-Dot rock.

An unimproved two-track road led to quite a location: A number of large, rim-rocked draws and canyons pulled steeply apart and formed some broken, splayed knolls and points, and jointed areas of juniper-studded canyons that plunged precipitously downward. I parked on one of the points and could see a large bulldozer working below me. The operator (also the mine attendant) disembarked and soon appeared, puffing after his hike up the fresh-cut road from below.

He was a pleasant young man, and we had a nice visit about the abundant rock piled about. "You can pick and choose any material you see here, or we can hike just around and under this point and you can select some stuff directly from the mine," he said helpfully.

Seeing the actual mine was of interest to me, so I said, "Let's walk down to the mine." It was not far. A sharp, downhill right turn led straight into a hillside cut littered with broken rock, an interesting mix of agate, jasper and leaverite.

An area had been excavated into the face of the point above us, and a more or less flattened floor had been formed. On three sides, the ground fell away into steep canyon walls below us. A ledge 8 or 10 feet high, opposite the excavated face, had been formed by digging, and part of the original ridge contour was still visible. It seemed to contain the main source of the popular agate and jasper rock. Beyond the agated ridge was space and blue sky. Collectible rock was all around, but the really good stuff seemed a little less abundant.

"This is an ancient collecting site," said the attendant. "Indian peoples gathered agate here centuries ago. This was a popular rock for tools and arrowheads. No backhoes or bulldozers back then, but they had another method to get the rock out. See that small, chunky, black stuff in there under that hollowed out ledge?" It was plainly visible, mixed into the layers of dirt and broken rock. "That's charcoal from old campfires built by the Indians to heat up the rock," he explained. "After the rock was very hot, they would throw water on it."

The sharp expansion and contraction caused by the heating and abrupt cooling caused the rock to split and fracture into manageable pieces for sorting and collection. It was a very ingenious and effective method, if not a little scary. But it had clearly worked, because we could see the cavelike cavity the Indians had carved into the hard ledge of agate. It was perhaps a body length deep, and just high enough to stoop or kneel in.

We went on to discuss whether trade routes might have existed and who swapped what with whom. Was the agate stockpiled, and are there caches of dazzling quality and quantity stashed in bulging mounds, awaiting some lucky rockhound's fortuitous discovery?

I collected some rock from the mine, both agate and jasper, and some small, very nice white and strawberry-veined pieces of tumbling size. Back at the parking area, I noted that the rock around us graded all the way from heavily included opaque gold and brown jasper to blue-white and brown agate. Finding pieces with good polka-dots in quality material took some looking, but there was lots to look through. I selected a nice chunk or two, and was on my way with some interesting history and some nice Polka-Dot rock.

Back to jasper, Mother Nature's SiO_2 recipe. It's a versatile one! Add a dash of this or that mineral or element to the formula, with some slight adjustments of heat and pressure, and we can have quartz crystals, chalcedony, jasper, flint, chert, and more! Jasper combines Earth's two most abundant elements, silicon and oxygen. It is estimated that the element silicon constitutes nearly 28 percent of Earth's crust. After oxygen, it is the second most-abundant element. Furthermore, it is estimated that approximately 12 percent of the lithosphere (crust) is comprised of the oxide SiO_2. Add some water (on average about 6 percent) to the formula, and we have opal, with its shimmering fire!

Since ancient times, jasper has been used and appreciated as a material for ornamental objects—mosaics in particular—by many societies. The ages have produced a seemingly endless variety of this multicolored stone, enough to excite and please ancient and modern folk alike.

I find collecting and cutting jasper to be most gratifying (despite some of its aggravations), not only for its exciting array of color and pattern, but because it is readily available. One does not have to trek to Sri Lanka to collect, and some really special and unique specimens are obtainable across the country, many as yet undiscovered. Indeed, the possibility of finding new and exciting silica drives many rockhounds into the backcountry.

Some would call jasper the Rodney Dangerfield of the mineral world. Whether or not you respect it, all can at least enjoy jasper for its endless play of color and combination: bold, carnivallike color at one extreme, to subtle, muted tones with the nuance of the most delicate, earthy hue at the other. All compliments of nature's SiO_2 and the ages.

As common as it is, jasper still manages to stir our senses. It somehow speaks to us and occupies at least some portion of our collections. What would we rockhounds do without it?